Foundrymen's Handbook

BASED ON DATA SHEETS
FROM *THE FOUNDRY*

REVISED AND SUPPLEMENTED
TO REPRESENT AND INTERPRET
MODERN PRACTICE

FIRST EDITION
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PREFACE

TO ENABLE foundrymen to compile a notebook of classified information relating to all phases of casting production, *The Foundry* inaugurated the publication of a series of Data Sheets in September, [illegible]. These have been continued with unbroken regularity and a tremendous amount of valuable data has been accumulated. Specially inserted in each issue of *The Foundry*, these data sheets are marked for easy clipping and are printed only on one side of the page. Gathered together in loose leaf notebook form, these Data Sheets now constitute the most valuable section of the reference libraries of many foundrymen. However, those who have not had access to these Data Sheets from the time they were originally issued, or who have failed to preserve them, have been insistent in their demands that they be made available to them in some permanent form. Therefore, this FOUNDRYMEN'S HANDBOOK has been compiled from these Data Sheets, some of which, published ten or more years ago, have been eliminated because they reflect obsolete practice and others have been revised to accord with modern methods.

Foundry work involves principles of almost every branch of engineering to which the skilled foundrymen must add a knowledge of the essentials of chemistry, metallurgy and pattern design and construction. The miscellaneous character of the information herein presented reflects the wide diversity of general and scientific data that should be available to every foundryman and should find a place in every casting plant. At least an elementary knowledge of foundry work is essential for the patternmaker and he also will find this handbook a valuable addition to his reference library. A large part of the data herewith

presented represents original research and study; some of it detail in concise form, practice that has been standard for many years; man of the calculations are included because of their direct bearing upo foundry and pattern shop problems, while the specifications represent th most recent standards adopted or revised by the societies by which the have been prepared.

An attempt has been made to credit the many and diversifie sources of information contained in this handbook, but unfortunatel this listing is incomplete. Therefore, to all contributors collectivel are extended hearty thanks and appreciation of their efforts which hav made this handbook possible and the same sentiments undoubtedly wi be expressed by those interested in the progress of foundry practic who may have occasion to refer to this work.

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SECTION I

GENERAL FOUNDRY DATA

USEFUL FORMULAS

Wax Vents for Cores

Paraffine wax largely is used for making wax vents for cores, and two pounds of wax will make 35 feet of ¼-inch taper. The wax first is softened by being placed in warm water, so that it can be squeezed through the vent machine. The tapers are coiled for convenient storage, while warm and soft and previous to use are softened by immersion in warm water.

Composition Vents

A composition of equal parts of beeswax and rosin also makes an excellent wax vent. The wax should be melted first, then the rosin added as a powder, the mixture being well stirred meanwhile. This composition does not soften the cores like pure wax, as the rosin hardens the core and corrects this fault of the wax. Paraffine wax may be substituted for the beeswax, but it is not as good. However, when it is necessary to use the harder wax, the tapers should be formed by dipping cotton wick into the melted paraffine as the composition is too brittle to use without support. When beeswax is used, the tapers can be formed by squeezing through a vent machine.

Coatings for Steel Cores

Add shellac varnish to the regular plumbago core wash until the mixture is thick enough to form a thin and perfect coating on the steel when dipped. When dry, re-dip until the required thickness is obtained. Another method of preparing steel shapes for use as cores is to coat with linseed oil, and while wet, dust with dry, sharp sand, and bake in the oven. Silicate of sodium (water glass) has also been found of value as a coating for steel cores. When the steel is to be burned onto cast iron, it first is coated with silicate of sodium, and while tacky is dusted with finely powdered ferro-manganese. Before being placed in the mold the treated steel is thoroughly dried.

Facing Mixture for Skin-Dried Molds

	Parts
Old molding sand	12
New molding sand	6
Lake sand	2½
Sea coal	2
Flour	½

Mix thoroughly and wet with clear water until as damp as ordinary molding sand. When the mold is made, brush on dry plumbago and polish with the hand; then paint with molasses water and dry until a hard skin is formed.

USEFUL FORMULAS
(Continued)

Foundry Refractories

Fire brick should always be kept dry, as moisture, especially in cold weather, greatly injures the brick. The refractoriness of the fire clay in which the bricks are laid should be equal to that of the bricks, otherwise the clay will melt out, and the heat will penetrate to the shell of the furnace. A brick-to-brick joint should be made whenever possible. The bricks are dipped in a thin clay mixture and close contact is obtained by rubbing the bricks together.

Fire clay brick should be laid with finely ground fire clay, and silica brick should be laid with silica cement. All newly lined furnaces should be heated slowly to expel the moisture. Furnaces lined with silica brick should always be heated and cooled slowly and uniformly, as sudden variations of temperature cause the brick to spawl.

Proportions of Clay to Brick

In laying 1,000 fire bricks, from 250 to 350 pounds of fire clay or silica cement are required. The weight of ordinary fire clay brick averages 150 pounds a cubic foot and silica brick, 130 pounds a cubic foot. One square foot of 4½-inch wall requires seven bricks, and one square foot of 13½-inch wall requires 21 bricks; 1,000 bricks, closely stacked, total 56 cubic feet.

Chrome Brick

Chrome bricks are very refractory, dense in structure and neutral. They are practically infusible and are useful in making emergency repairs on a hot furnace as they are not affected by sudden changes of temperature. Chrome bricks, when next to the shell of the furnace, should be laid in magnesite cement.

USEFUL FORMULAS

(Concluded)

Carborundum Brass Furnace Lining

Mix together thoroughly the following ingredients:

	Parts
Carborundum fire sand	[illegible]
Dry powdered fire clay	[illegible]

Wet to the consistency of molding sand with a mixtu[illegible] and silicate of soda, in the proportions of half and half. [illegible] ture is used to form furnace linings by being rammed [illegible] between the furnace shell and a sheet iron or wooden f[illegible] determines the size of the furnace. This form is afterwar[illegible]

Producer Groutings

An elastic filling to be used between the fire bri[illegible] and the shell of producers is made by mixing thoroughl[illegible] condition the following:

	Parts
Silica sand	[illegible]
Dry fire clay	[illegible]

Add to this mixture 20 parts of coal tar and thorou[illegible] porate, using heat if necessary. The mass should not be [illegible] is tamped in place like sand.

Furnace Cement

	Parts
Dry pulverized fire clay..................................	[illegible]
Oxide of manganese	[illegible]
Borax	[illegible]
Salt	[illegible]

Mix with water to a paste, apply to the cracks and heat gradually.

Ladle Daubing

A daubing for small ladles that has met with con[illegible] success is made as follows:

	Parts
Loam sand	[illegible]
Sharp or silica sand	[illegible]
Dry core compound	[illegible]

Mix, and dry thoroughly after application to the ladles.

DATA ON FUELS

Comparative Heat Values of Fuels

The unit of heat generally used for practical purposes is known as the British thermal unit (B. t. u.) and represents the amount of heat required to raise 1 pound of water, 1 degree Fahr., when at a temperature of 60 degrees Fahr. Its mechanical equivalent is 772 foot-pounds. A comparison of the heat values of various fuels is made in the following table:

Fuel	Heat Value in British Thermal Units, Per Pound.
Anthracite coal	12,900 to 14,800
Acetylene gas	20,700
Bituminous coal	12,500 to 16,200
Charcoal	13,700
Coke	12,000 to 14,500
Carbon, complete combustion	14,500
Coal gas	19,850
Hydrogen to water	52,740
Peat	7,400 to 10,200
Wood	7,400 to 7,800
Natural gas	22,000
Marsh gas	23,500

The thermal value of any fuel will vary according to the amount of moisture contained therein.

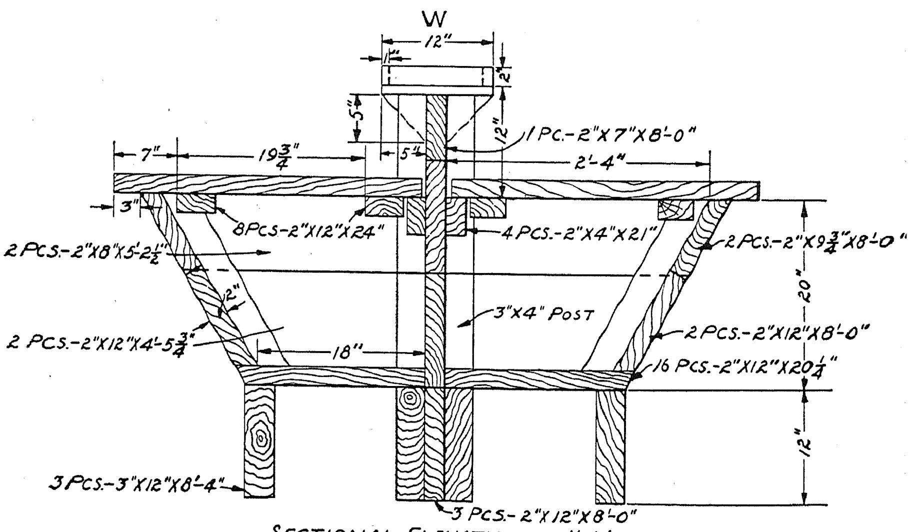
Weights of Different Fuels and the Space Required for Storage

Fuel	Weight, Pounds Per Cubic Foot.	Cubic Feet Storage Space, Per Ton of 2,240 Pounds
Anthracite coal, market size, piled loosely	52 to 56	40 to 43
Bituminous coal, broken, piled loosely	47 to 52	43 to 48
Dry Coke	23 to 32	80 to 97

From 100 net tons of coking coal there are produced 65 tons of coke in beehive ovens, and in by-product ovens there are obtained 75 net tons of coke, 1,000 gallons of tar, 2,500 pounds of sulphate of ammonia, and 450,000 cubic feet of illuminating gas.

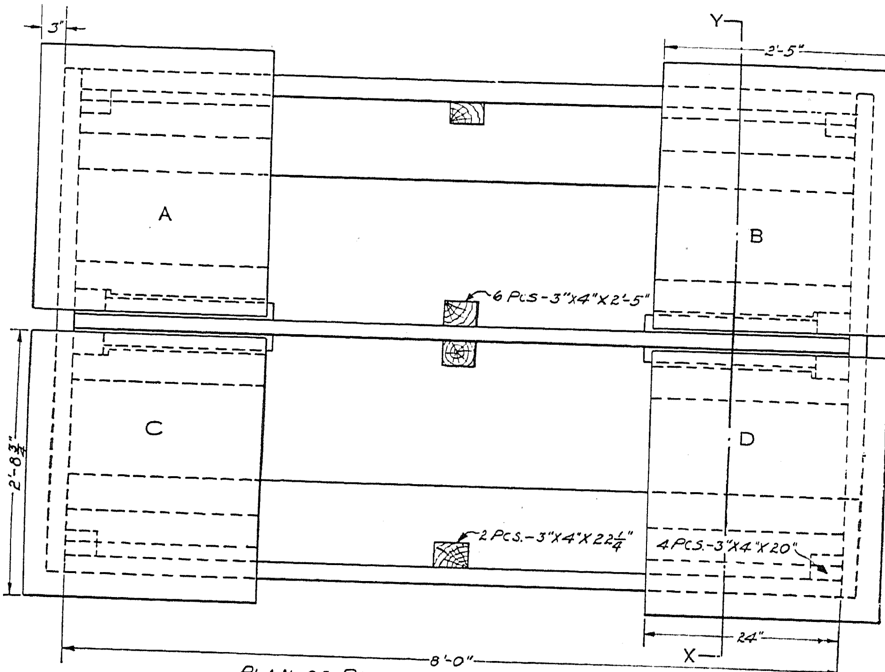
DETAILS OF A COREMAKER'S BENCH

The three drawings on pages 6 and 7 present complete details necessary for the construction of a coremaker's bench. This bench consists essentially of two sand hoppers with a capacity of approximately 21 cubic feet, each supported on 3 x 12-inch yellow-pine foundation stringers. Edge-bolted 2 x 12-inch yellow pine planks form the dividing wall between the two sand hoppers, and also support the shelf, *W*, designed to accommodate the coremaker's tools. Four men work at the bench, at the points lettered *A, B, C* and *D*, respectively, on the upper drawing on page 7. Each man has a 29 x 32¾-inch working platform at his disposal. It is supported by the sides of the sand hopper and may be moved to any desired position.

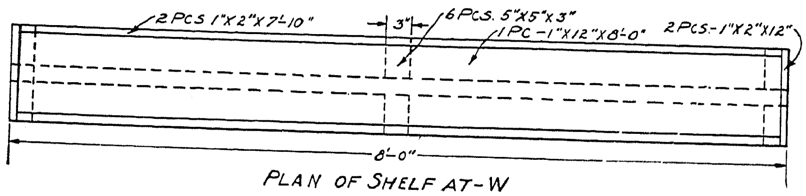


SECTIONAL ELEVATION AT X-Y

DETAILS OF A COREMAKER'S BENCH
(Concluded)



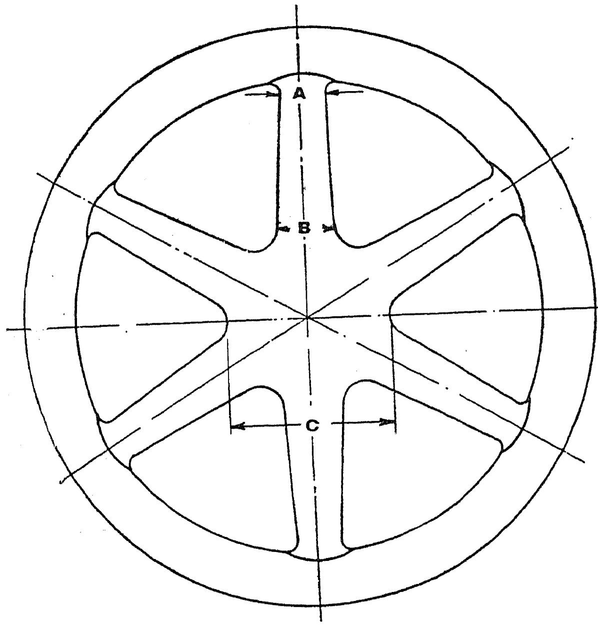
PLAN OF BENCH WITH SHELF REMOVED

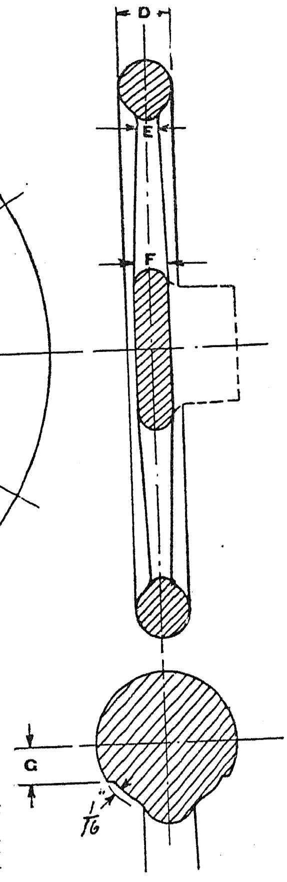


PLAN OF SHELF AT-W

DIMENSIONS OF STANDARD HAND WHEELS

Make hubs loose and interchangeable to permit use of hubs of different lengths and diameters on either or both sides of the wheels. For hand wheels with finished rims allow for 1/16-inch recess as shown. For rough hand wheels make rim full round section.





Size of wheel	No. of arms	A	B	C	D	E	F	G
5-in.	4	$\frac{9}{16}$	$\frac{5}{8}$	2	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{16}$
6-in.	4	$\frac{5}{8}$	$\frac{13}{16}$	$2\frac{1}{8}$	$\frac{13}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{32}$
7-in.	5	$\frac{11}{16}$	$\frac{7}{8}$	$2\frac{1}{4}$	$\frac{7}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{4}$
8-in.	5	$\frac{3}{4}$	$\frac{15}{16}$	$2\frac{5}{16}$	$\frac{15}{16}$	$\frac{5}{16}$	$\frac{7}{16}$	$\frac{1}{4}$
9-in.	6	$\frac{13}{16}$	1	$2\frac{7}{16}$	1	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{9}{32}$
10-in.	6	$\frac{7}{8}$	$1\frac{1}{16}$	$2\frac{1}{2}$	$1\frac{1}{16}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{5}{16}$
11-in.	6	$\frac{15}{16}$	$1\frac{1}{8}$	$2\frac{5}{8}$	$1\frac{1}{8}$	$\frac{7}{16}$	$\frac{9}{16}$	$\frac{5}{16}$
12-in.	6	1	$1\frac{3}{16}$	3	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{11}{32}$
14-in.	6	$1\frac{1}{16}$	$1\frac{1}{4}$	$3\frac{3}{8}$	$1\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{8}$
15-in.	6	$1\frac{1}{8}$	$1\frac{5}{16}$	4	$1\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{8}$
16-in.	6	$1\frac{3}{16}$	$1\frac{3}{8}$	$4\frac{1}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{13}{32}$
18-in.	6	$1\frac{1}{4}$	$1\frac{1}{2}$	$4\frac{1}{4}$	$1\frac{1}{2}$	$\frac{9}{16}$	$\frac{11}{16}$	$\frac{7}{16}$
20-in.	6	$1\frac{5}{16}$	$1\frac{5}{8}$	$4\frac{1}{2}$	$1\frac{1}{2}$	$\frac{9}{16}$	$\frac{11}{16}$	$\frac{7}{16}$

PICKLING SOLUTIONS FOR IRON

When cast or malleable iron has been cleaned preliminary to galvanizing operations, or for any other purpose, and it becomes necessary to use a pickling solution, the first consideration is to remove oil and grease. To accomplish this the castings are thoroughly washed in the following solution:

Ordinary soda lye	38 pounds
Hot water	100 gallons

Any proportion of the above may be used. The castings are immersed from 5 to 10 minutes, or longer if the grease is caked on, after which they are removed and washed in hot water. The precautions to be observed are to keep the lye solution clear of floating oil or fat by skimming frequently; and to renew the solution whenever it becomes greasy or brownish in color. After being cleaned of grease and washed in hot water, the castings are immersed in the following pickle:

Water	76½ gallons
30 per cent hydrofluoric acid	15 gallons

The commercial hydrofluoric acid is used, and the strength of the pickling solution should be about 1.026 at 80 degrees Cent. If the density should be less than this, add acid to bring up the strength. When the solution gets brownish and deposits form upon the castings, it must be renewed. The acid bath is worked at the same temperature as the alkaline bath, which ranges from 60 to 80 degrees Cent. During immersion in the acid the castings should be well shaken and dipped several times to bring the solution into contact with every part.

The castings are removed from the acid solution after they are clean and are rinsed well in hot water. The temperature of the water should be around 80 degrees Cent. After thorough washing the castings are immersed in the following solution to neutralize any acid:

Lime, either quick or air slaked	20 pounds
Water	100 gallons

When the solution changes from a milky to a brownish color it must be renewed. Litmus tests will show the condition of the solution and when it loses alkalinity it must be run off, the tank thoroughly washed out and new solution prepared. From the neutralizing tank the castings are placed on an inclined screen and allowed to dry.

IRON AND STEEL ETCHING SOLUTIONS

TABLE GIVING ETCHING SOLUTIONS FOR IRON AND STEEL WITH THEIR CHEMICAL COMPOSITIONS

ETCHING REAGENT	COMPOSITION	PROPOSED BY	USED FOR SHOWING	REMARKS
10% Nitric acid	10% Nitric acid, HNO_3 90% Alcohol, C_2H_6O	Sauveur	General structure of iron and steel	
Picric acid	5 gms. Picric acid, $C_2H_6(NO_2)_3OH$ 95 cc. Alcohol, C_2H_6O	Igevsky	General structure of iron and steel	Bottle should be well stoppered
Nitric acid	Nitric acid, HNO_3 concentrated	Sauveur	General structure of iron and steel	1.42 specific gravity
Sodium picrate	2 gms. Sodium picrate, Na $C_6H_2(NO_2)_3$ 24.5 gms. Sodium hydrate NaOH 73.5 cc. water	Kourbatoff	Cementite	Solution to be boiling
Steads reagent	10 gms. Cupric chloride, $CuCl_2$ 40 gms. magnesium chloride, $MgCl$ 20 cc. Hydrochloric acid, HCl Alcohol, C_2H_6O, to make 1000 cc.	Stead	Phosphorus	Salts dissolved in hot water, and alcohol, added to make 1000 cc.
Heat tint	Molten bath of tinmans solder	Stead	Phosphorus, ferrous sulphide, manganese sulphide	
Silk printing	10 gms. Mercuric chloride, $HgCl_2$ 20 cc. water 100 cc. Hydrochloric acid, HCl	Heyn and Bauer	Sulphur	Solution Impregnated on strips of silk
Acid solution of lead, mercury or cadmium	Solution acidified with Hydrochloric acid or Nitric acid, HCl or HNO_3	Law	Sulphur	Mixed with gelatine
Ethyl alcohol	Alcohol, C_2H_6O, with 1% solution of organic acid (picric)	Rohl	Ferrous sulphide Manganese sulphide	
10% alcoholic solution of nitric acid	90 cc. Alcohol, C_2H_6O 10 cc. Nitric acid, HNO_3	Sauveur	Wrought iron (Ferrite grains)	
5% alcoholic solution of picric acid	5 cc. Picric acid, $C_6H_2(NO_2)_3OH$ 95 cc. Alcohol, C_2H_6O	Sauveur	Wrought iron (Ferrite grains)	
Bitartrate of potassium	Bitartrate of potassium, $KHC_4H_4O_6$	Le Chatelier	Ferrite	
Soda and lead nitrate	Soda, 50% Lead nitrate, 10%	Le Chatelier	Cementite and Pearlite	
Hydrochloric acid and cupric chloride	10% gaseous Hydrochloric acid, HCl 5% $CUCl_2$, Cupric chloride	Le Chatelier	Annealed steel martensite, austenite, troostite, sorbite	
Alcohol and acid solution in acetic anhydride	1 part $C_5H_{11}OH$, Amyl Alcohol 1 part C_2H_5OH, Ethyl Alcohol 1 part CH_3OH, Methyl Alcohol 1 part 4% HNO_3, Nitric acid in $C_2H_4O_2$, Acetic anhydride	Kourbatoff	Hardened steel	Solution to be prepared just before use
Hydrochloric acid and alcohol	1 part Hydrochloric acid, HCl 99 parts Ethyl alcohol C_2H_6O	Heyn	Hardened steel	
Hydrochloric acid and alcohol with electric current	1 part Hydrochloric acid, HCl 500 parts distilled water and electric current	Heyn	Hardened steel	
10% HCL, hydrochloric acid in H_2O, water	10% Hydrochloric acid HCl 90% water	Osmond	Martensite and austenite	
5% Metanitro-benzol sulphonic acid	Metanitrobenzol sulphonic acid, $C_6H_4NO_2HSO_3$	Benedicks	Martensite-austenitic steels	
Sulphurous acid	Saturated solution prepared and using 3 or 4% in water	Hilbert and Clover-Glauert	Non-pearlitic steels	

IRON AND STEEL ETCHING SOLUTIONS
(Concluded)

ETCHING REAGENT	COMPOSITION	PROPOSED BY	USED FOR SHOWING	REMARKS
Rosenhain and Haughton solution	30 gms. Ferric chloride, $FeCl_3$ 100 cc. concentrated Hydrochloric acid, HCl 1.0 gms. Cupric chloride, $CuCl_2$ 0.5 gms. Stannous chloride, $SnCl_2$ and water to make 1000 cc.	Rosenhain and Haughton	Ferrite and pearlite	
Heyns reagent	10 gms. Double Chloride of Copper and Ammonia, $CuCl_2NH_4Cl$ per 100 cc. water	Heyn	Neumann lines, etching figures and pits	
20% solution of sulphuric acid	20 cc. sulphuric acid, H_2SO_4 80 cc. Water	Stead	Etching pits in wrought iron	Cleaned in Nitric acid, HNO_3
Hydrogen peroxide and sodium hydrate	10 cc. Hydrogen peroxide H_2O_2 20 cc. 10% Sodium hydrate, NaOH, and water	Yatesevitch	High speed steel Free carbide	Preparation to be fresh every day
Cupric ammonium chloride	10% water solution of double Chloride of Copper and Ammonia $CuCl.,NH_4Cl.,6H_2O$	Heyn and Stead	Macrostructure, Etching pits in wrought iron	
20% solution nitric acid in water	20 cc. Nitric acid, NHO_3 80 cc. Water	Heyn and Stead	Macrostructure	
Tincture of iodine	Iodine, I, in Alcohol C_2H_6O	Osmond	General structure of iron and steel	
Steads solution	1.25 gms. Iodine, I 1.25 gms. Potassium Iodine, KI 1.25 gms. Water Alcohol C_2H_6O, to make 100 cc.	Stead	General structure of iron and steel	
Martins and Heyns solution (1)	1 part Hydrochloric acid, HCl, sp. gr. 1.19 100 parts alcohol, C_2H_6O	Martin and Heyn	General structure of iron and steel	
Martins and Heyns solution (2)	1 part Hydrochloric acid, HCl, sp. gr. 1.19 500 parts Water with electric current	Martin and Heyn	General structure of iron and steel	
Heyns solution	12 grains, Cupric ammonium chloride, $CuCl_2$ NH_4Cl, $6H_2O$ 100 grains distilled water	Heyn	General structure of iron and steel	
Neutral sodium picrate solution	Neutral sodium picrate solution, $C_6H_2(NO_2)_3Na$	Matweieff	Distinguish between iron phosphide and cementite	Solution to be boiling
Saturated solution of picric acid	Picric acid, $C_6H_2(NO_2)_3OH$ alcohol C_2H_6O	Robin	Austenite and Martensite	
Electrolytic etching	Sheet lead for electrode 10 gms. Ammonium chloride, NH_4 Cl. or Ammonium sulphate $(NH_4)_2SO_4$, per 100 cc. water, for electrolyte	Le Chatelier	General structure of iron and steel	4 or 5 volts with .001 to .01 amp. per sq. cm.
Hot etching	Calcium chloride, $CaCl_2$	Saniter	Steel structure	Molten to desired temperature
Hot etching	Gaseous Hydrochloric acid, HCl	Baykoff	Steel structure	
Nital	4% Nitric acid, HNO_3 96% Alcohol, C_2H_6O	Northrup and Knight	General structure of iron and steel	

USES OF IRON AND STEEL ETCHING SOLUTIONS

TABLE GIVING THE USES OF VARIOUS ETCHING SOLUTIONS AND THE STRUCTURES REVEALED BY EACH

CONSTITUENT	REAGENT	TIME	WASH	STRUCTURE	METHOD	REMARKS
General structure of iron and steel	Nitric acid and alcohol	10 sec.	Alcohol	Grain boundaries	Immersion	
General structure of iron and steel	Picric acid and alcohol	30 sec.	Alcohol	Grain boundaries	Immersion	Ferrite not attached
General structure of iron and steel	Concentrated nitric acid	1 sec.	Abundant water	Grain boundaries	Immersion	Ferrite not attached
Cementite	Sodium picrate	5 to 10 min.	Alcohol	Cementite brown Ferrite unaffected	Immersion	Solution to be boiling
Phosphorus	Stead's reagent	60 sec.	Boiling water and methylated alcohol	Segregated spots and strips	Covered with a layer of reagent	Copper is deposited on the phosphorus
Phosphorus	Heat-tinting	Depending on color		Segregated spots and strips	Placed on surface	Yellow-brown to red and purple; or purple or blue on yellow-brown back ground
Ferrous Sulphide	Heat-tinting	Heat until brownish tint		Segregated spots and strips	Placed on surface	Purple
Manganese sulphide	Heat-tinting	Heat until brownish tint		Segregated spots and strips	Placed on surface	White
Sulphur	Printing with silk			Spots	Pressed on silk	Spots appear on silk
Sulphur	Printing with silver bromide paper			Stains, dark	Pressed on paper, moisten with dilute sulphuric acid	Appear dark on paper
Sulphur	Gelatin with acid solution of lead, mercury or cadmium			Stains, yellow, of lead, mercury, or cadmium sulphides	Cover surface	
Wrought Iron	10% sol. of nitric acid and alcohol	10 to 15 sec.	Alcohol	Grains with slag inclusion dark	Immersion	
Wrought Iron	5% sol. of picric acid and alcohol	30 sec.	Alcohol	Grains with slag inclusion dark	Immersion	
Pearlite	Nital	8 to 10 sec.	Alcohol	Laminated strips of iron carbide and iron	Immersion	Iron white Iron carbide dark
Pearlite	Picric acid	20 sec.	Alcohol	Laminated strips of iron carbide and iron	Immersion	Ferrite or Cementite bright, pearlite dark

USES OF IRON AND STEEL ETCHING SOLUTIONS
(Concluded)

CONSTITUENT	REAGENT	TIME	WASH	STRUCTURE	METHOD	REMARKS
Sorbite	Nital	7 to 8 sec.	Alcohol	Granular	Immersion	Ill defined
Sorbite	Picric	15 sec.	Alcohol	Granular	Immersion	Ill defined
Troostite	Nital	2 to 3 sec.	Alcohol	Irregular and granular	Immersion	Darker than Martensite or Sorbite accompanying it
Troostite	Picric	5 sec.	Alcohol	Irregular and granular	Immersion	Darker than Martensite or Sorbite accompanying it
Martensite	Nital	5 sec.	Alcohol	Intersecting needles parallel to sides of triangle; zig-zag lances and shafts with austenite	Immersion	Light color
Martensite	Picric acid	10 sec.	Alcohol			
Austentite	Nital	3 to 5 sec.	Alcohol	Polyhedra often worse much twinning in presence of Martensite		Bright
Austentite	Picric	5 to 6 sec.	Alcohol	Polyhedra often worse much twinning in presence of Martensite		Bright
Manganese	Nital	5 sec.	Water	Grains		Bright
High Speed Steel	Yatesevitch reagent	10 to 12 sec.	Alcohol and water	Web structure of free cementite		Dark
Cast Iron	Common reagents	10 sec.	Alcohol	Grains and graphite strips in gray cast iron spots of carbon in malleable cast iron	Immersion	
Microstructure	Double chloride of copper and ammonia fallowed by 10% solution Nitric acid	3 min. 30 min.	Alcohol	Grains	Immersion	
Microstructure	Cupric ammonium chloride	2 min.	Water	Grains	Immersion	
Microstructure	20% nitric acid; hydrochloric acid dilute; sulphuric acid dilute	10 min.	Water	Grains	Immersion	

DATA ON CHIMNEY DESIGN

Theoretical Draft of Chimneys

Chimneys are required, in general, for two purposes, viz.:

1—To provide a draft and produce combustion.

2—To carry away gases or the products of combustion.

The first requirement governs the height and the second the area of a chimney.

Draft is the difference in pressure produced by the difference in weight between the hot gases inside the chimney and an equivalent column of outside air. Draft in chimneys is analagous to difference of head in water.

The intensity of draft is measured in inches of water and is determined theoretically by the following formula:

$$D = 0.518\ P_o H \left[\frac{1}{T_o} - \frac{1}{T_c}\right]$$

where D=intensity of theoretical draft in inches of water.

H=height of chimney in feet.

P_o=observed atmospheric pressure in pounds per square inch.

T_o=absolute temperature of outside air in degrees Fahr.,

T_c=absolute temperature of chimney gases in degrees Fahr.

For convenience let

$$K = 0.518\ P_o \left[\frac{1}{T_o} - \frac{1}{T_c}\right]$$

Then D=KH.

Assuming an observed atmospheric pressure of 14.7 pounds per square inch, Fig. 1 gives the values of K for various chimney gas temperatures with the observed outside air temperatures as indicated.

DATA ON CHIMNEY DESIGN
(Continued)

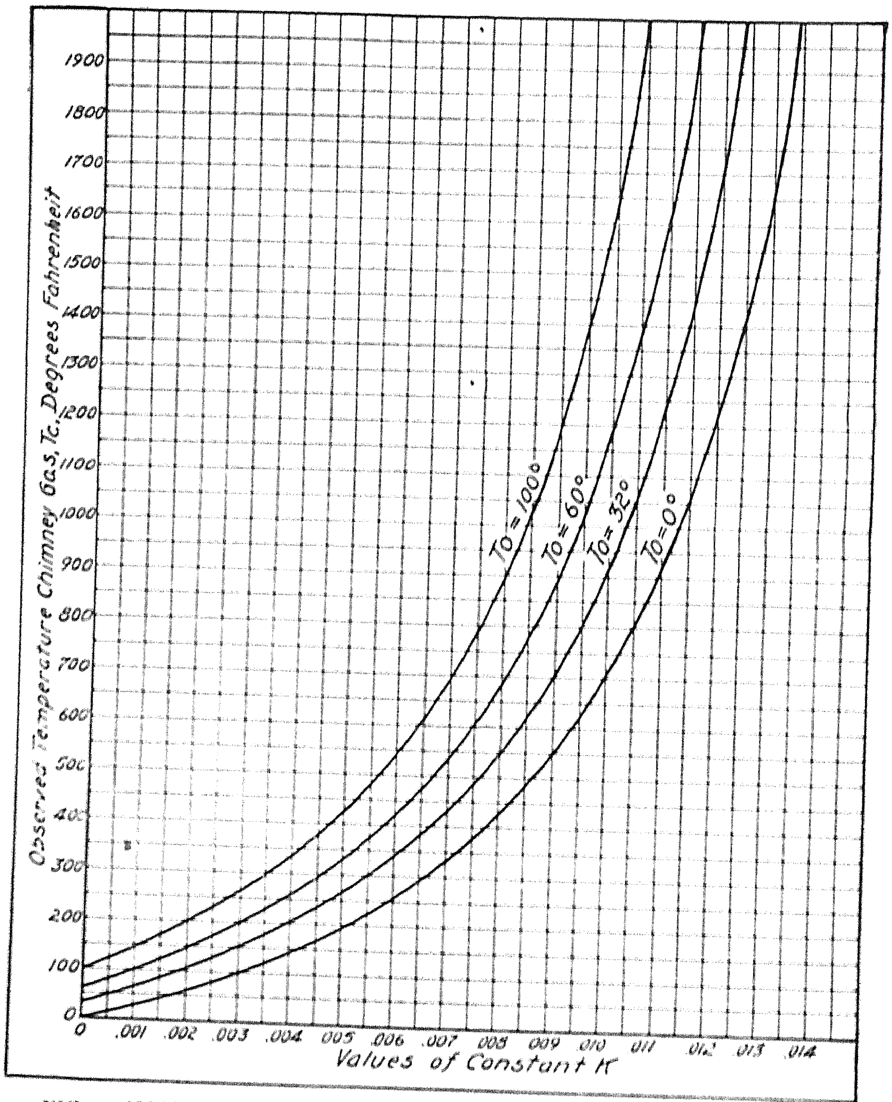


FIG. 1—VALUES OF THE CONSTANT K MAY BE DETERMINED FROM THIS CURVE

DATA ON CHIMNEY DESIGN
(Continued)

Correction for Velocity Losses

The theoretical intensity of draft is correct only when there is no flow or circulation. When the gases are flowing, the theoretical value is decreased by the losses due to velocity and friction within the chimney. This difference is called the available draft.

$$D' = KH - (h_v + h_f)$$

where D'=available draft in inches of water,

h_f=loss due to friction in inches of water,

h_v=loss due to velocity in inches of water.

The loss of draft due to velocity within the chimney is determined by the formula

$$h_v = 0.1184 \frac{V^2}{T_c}$$

where V=mean velocity of chimney gases in feet per second.

Fig. 2 gives the values of h_v for various chimney gas temperatures with the different mean velocities as shown.

DATA ON CHIMNEY DESIGN
(Continued)

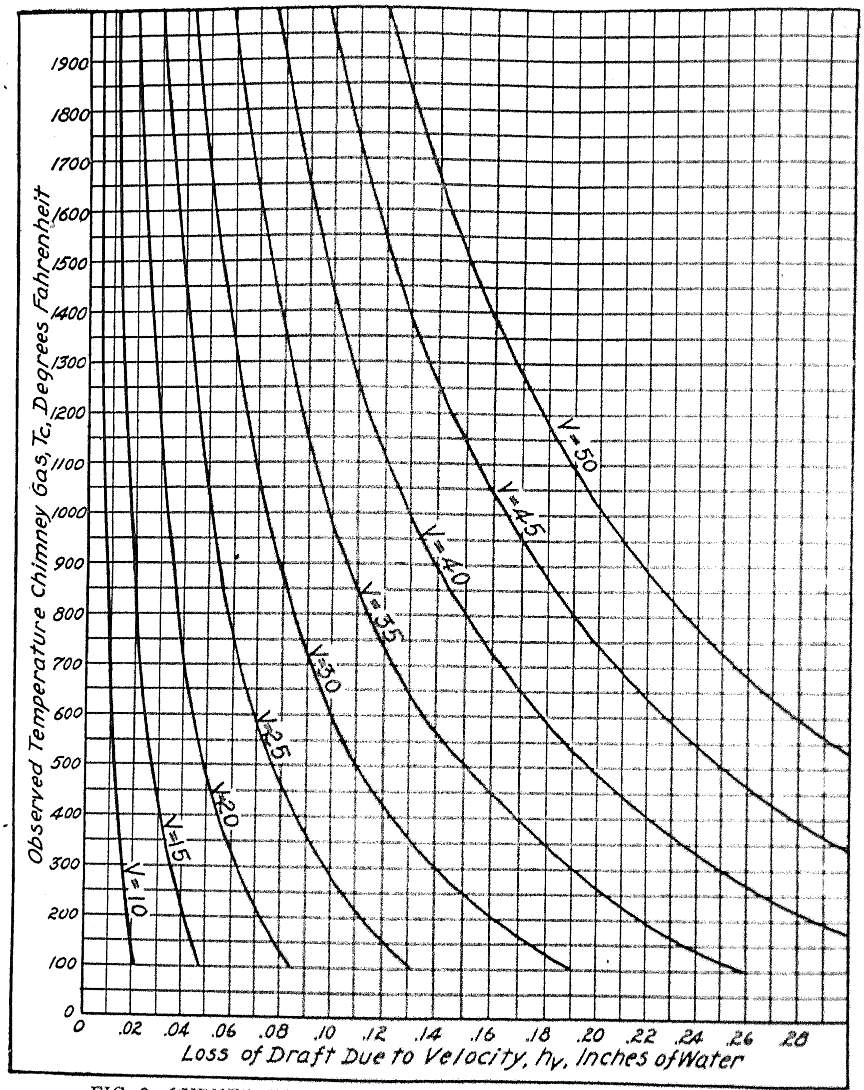


FIG. 2—CURVES GIVING LOSS OF DRAFT DUE TO VELOCITY

DATA ON CHIMNEY DESIG

(Continued)

CORRECTION FOR FRICTION LOS

The loss of draft due to friction within the the formula

$$h_f = 0.008 \frac{RV^2}{T_c}$$

where R=hydraulic radius of chimney= $\frac{\text{height}}{\text{diameter}}$

Assuming an average value of 20 for R,

$$h_f = 0.16 \frac{V^2}{T_c}$$

Fig. 3 gives the values of h_f for the various chim with the different mean velocities as shown.

HOW TO USE THE PLOTTED CUR

Example: Find the available draft of a chimn 10 feet in diameter, assuming an outside air tempe and a chimney gas temperature of 600 degrees, t the gases being 35 feet per second.

From Fig. 1, K for T_o=60 degrees and ' 0.00746. Whence D=200 × 0.00746=1.492 inch Fig. 2, h_v for the above assumptions is 0.137 anc 0.183. Hence D'=1.492—(0.137 + 0.183)=1.172

For approximate purposes D'=0.8D.

DATA ON CHIMNEY DESIGN
(Continued)

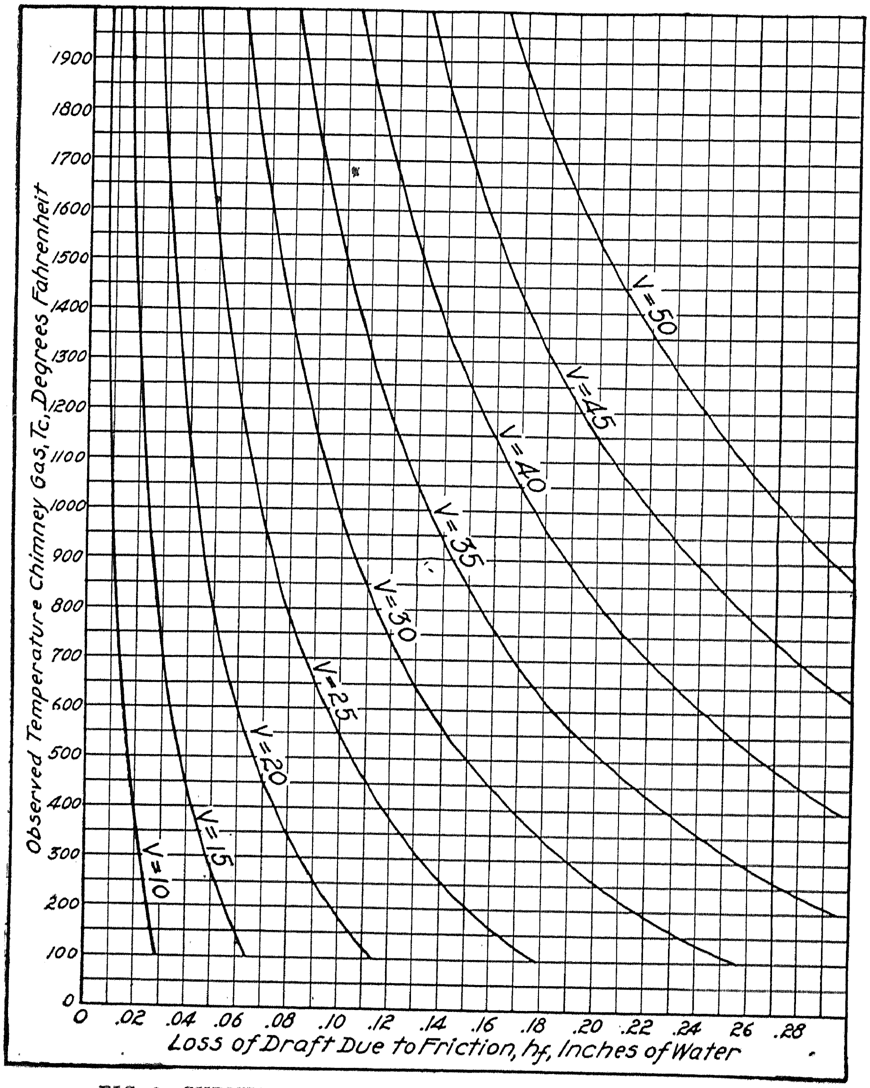


FIG. 3—CURVES GIVING LOSS OF DRAFT DUE TO FRICTION

DATA ON CHIMNEY DESIGN
(Continued)

Capacity of Chimneys

By the capacity of a chimney is meant the theoretical amount of fuel it will burn during a stated interval and consequently the theoretical amount of gases it will pass in the same time. The theoretical amount of fuel a chimney will burn is determined by the formula

$$W = W_o \sqrt{2gH \left\{ \frac{T_o}{T_c} - \left\{ \frac{T_o}{T_c} \right\}^2 \right\}}$$

when W=weight in pounds of the gases passing any point in the chimney per second,

W_o=weight in pounds of a cubic foot of air at T_o,

g=acceleration due to gravity feet per second per second.

H=height of chimney in feet,

T_o=absolute temperature of outside air in degrees Fahr.,

T_c=absolute temperature of chimney gases in degrees Fahr.

With an outside air temperature of 60 degrees and an average chimney gas temperature of 600 degrees the above formula reduces to

$$W_h = 362\ D^2\sqrt{H}$$

$$\text{whence } D = \sqrt{\frac{W_h}{302\sqrt{H}}}$$

where D=diameter of chimney in feet,

W_h= weight of gases passing any point in the chimney per hour.

It is more convenient, however, to express the capacity of a chimney in terms of horsepower equivalent. Assuming that each pound of coal requires 24 pounds of air to burn it and that each boiler horsepower requires 5 pounds of coal per hour, the horsepower, of a chimney equals

$$HP = \frac{385}{24x5} D \sqrt{H}$$

$$\text{whence } D = \sqrt{\frac{HP}{2.52\sqrt{H}}}$$

where HP=rated horsepower of chimney.

Fig. 4 shows the diameter of a chimney required for the different horsepower with the heights as indicated.

The formulas and the accompanying curve hold approximately true for oil, coke and gas burning equipment.

DATA ON CHIMNEY DESIGN
(Concluded)

Example: Find the diameter of a chimney 150 feet high with a horsepower equivalent of 1500.

Reading directly from the curve the diameter is given as 7 feet.

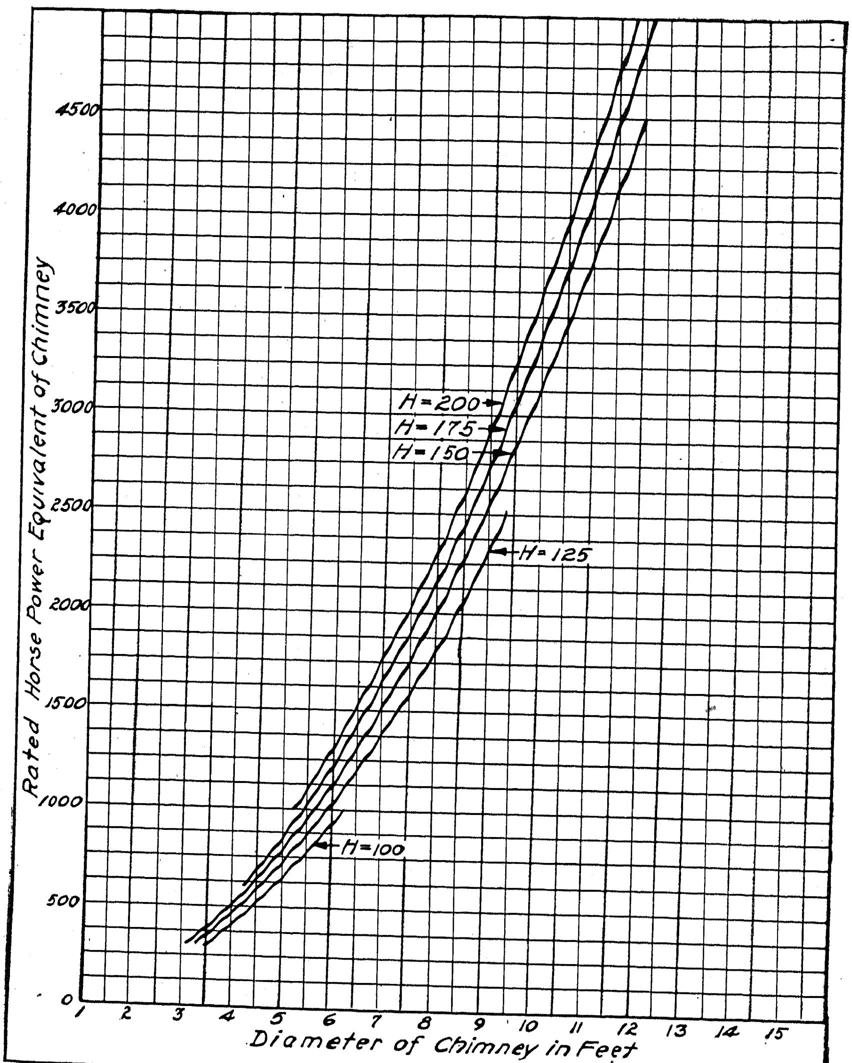


FIG. 4—CURVES GIVING DIAMETERS OF CHIMNEYS

METHODS OF FINDING AREAS OF IRREGULAR FIGURES

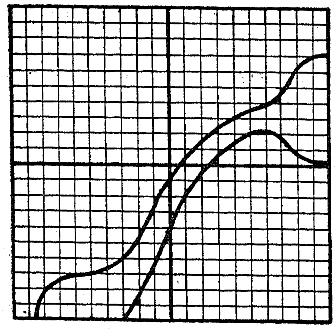


FIG 1

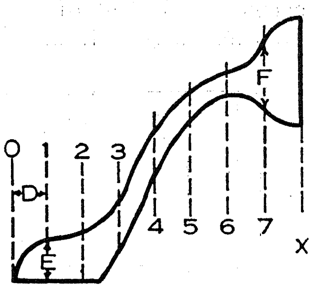


FIG 2

To find the area of an irregular figure, use one of the following methods:

Cross-Section Paper, Fig. 1

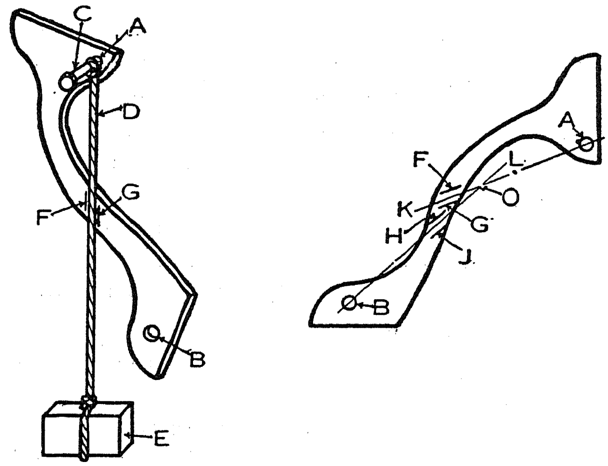
Draw the figure on cross-section paper. Count the number of whole squares and estimate the number of fractional parts of squares, and add the sum of all the fractional parts of squares to the number of whole squares. The area of the figure is the product of this sum multiplied by the area of one square. Thus, if cross-section paper ruled to tenths of an inch is used, the area will equal the sum of whole and fractional parts of squares multiplied by 0.01, that is, $(0.1)^2$.

Simpson's Rule, Fig. 2

Divide the length of the figure into an even number of parts of equal length, *D*, by parallel lines, called ordinates; add the lengths of the first and last ordinates included in the boundary, calling the sum *A*, that is $E + F = A$. (Note—*O* and *X*, which do not cross the figure, are not counted.) Then add the lengths between the boundaries of the even ordinates (2, 4, 6), and designate it the sum *B*, and then the odd ordinates except the first and last calling this sum *C*. Then the area of the figure $= \dfrac{A + 4B + 2C}{3} \times D$

Note.—The greater the number of division, the greater is the accuracy obtained.

METHOD OF FINDING THE CENTER OF GRAVITY OF IRREGULAR FIGURES



To find the center of gravity of any irregular figure, first lay out the figure on stiff paper, then cut it out and punch two holes, *A* and *B*, the diameter of which should be larger than that of the pin, *C*, then hang the body on the pin, *C*, at *A*, so that it can move freely. Then attach a cord *D*, with a weight, *E*, to *C*, in such a manner that they can also move freely. When the body, cord and weight have come to rest, mark on the body the lines, *F* and *G*, along the sides of the cord. Then in the same manner, suspending the body at *B*, obtain the lines *H* and *J*, laying down the body on a piece of paper draw A-K, passing midway between *F*. and *G*. Then draw *B-L*, and then the intersection of *A-K* and *B-L*, that is *O*, which is the center of gravity required.

MAKING CASTINGS OF UNIFORM THICKNESS F BLOCK PATTERNS

The illustrations on page 25 show a reliable method ducing castings of uniform thickness from solid patter method may be applied to open work, such as heating-stove to solid work, such as the oven doors of cooking ranges.

The first step is to make a wood pattern of the shape a desired. The face of this pattern is the same as that of a lc tern of like design. At the back, however, the pattern is lowed out. This pattern is attached solidly to a board, as s the upper view on page 25. This board is fitted with pins the drag with which it is to be used.

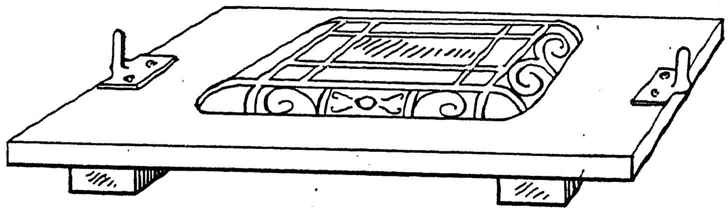
When molding by this method, the drag is clamped to tl and the sand is rammed hard. This point is important an not be overlooked. The pattern is drawn in the usual way.

The thickness of the casting section is determined by th ness of clay that is used in molding process. The clay i out in sheets with an ordinary rolling pin, on a board havir strips on its sides. These strips are the same thickness as tion desired in the casting. The board is shown in the low on page 25. It should be approximately 18 inches long and wide while the strips can be of 1-inch material and of tl thickness as the casting section.

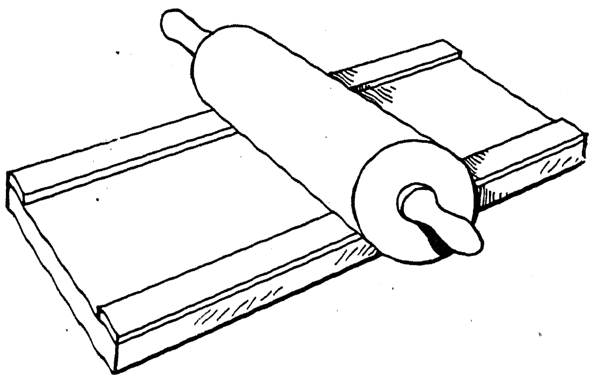
The mold is next lined with strips of clay cut from that is rolled out on the board described. This results in of clay of a unform thickness in the drag. The cope is ran the usual way, gated and vented and set aside. The cla moved, the drag is shaken-out and a new drag is made pattern board, as would be done in ordinary practice. Tl then is closed and is ready for pouring.

Potter's clay gives good results in molds of this kind. I be tempered with water firm enough to handle convenien preferably should be dusted with facing before rolling out board. It is also advantageous to varnish the rolling pin clay board as this prevents the clay from adhering.

MAKING CASTINGS OF UNIFORM THICKNESS FROM BLOCK PATTERNS
(*Concluded*)

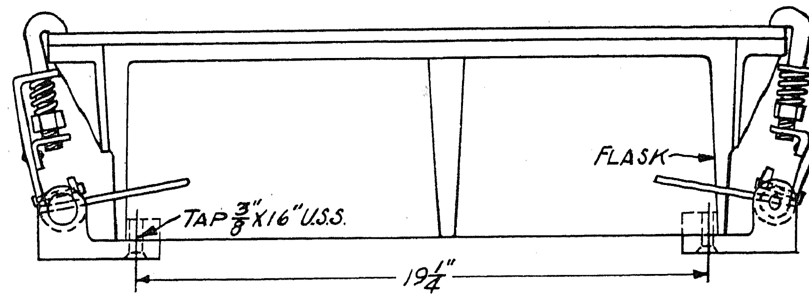


BLOCK PATTERN ATTACHED TO BOARD



CLAY THICKNESS BOARD

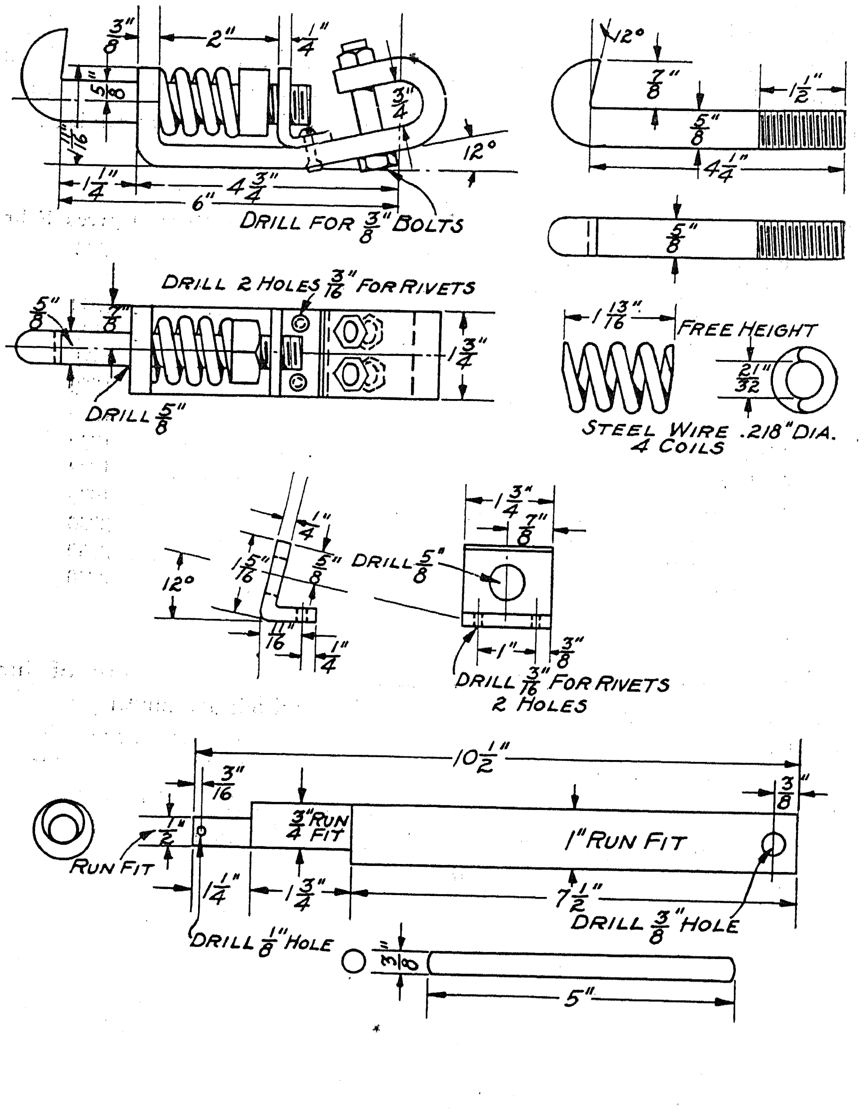
CLAMPING DEVICE FOR CORE PLATE



The accompanying illustration shows a core plate clamping device the details of which appear on page 27. As the illustrations show, the device is quite simple and easily made. It consists substantially of a bracket fastened to the bottom of the flask. This bracket carries an eccentric shaft that is operated by a hand lever. The action of the eccentric shaft draws down a steel plate that carries a hook clamp which projects over the core plate. The hook clamp is provided with a spring and an adjusting nut which relieves undue strain on the eccentric shaft.

CLAMPING DEVICE FOR CORE PLATE

(Concluded)



TEMPERATURE MEASUREMENTS BY COLORS

According to several authorities, the temperature of a heated body may be judged approximately by the eye, by the amount of light emitted when viewed in the dark, and the following table has been compiled to assist in gaging temperatures where greater accuracy is not required, or where more precise methods are not available:

Appearance of heated body	Temperature, degrees Fahr.
Faint red	878
Dull blood red	990
Full blood red	1050
Dull cherry red	1195
Full cherry red	1375
Light cherry red	1550
Deep orange	1640
Light orange	1730
Yellow	1832
Light yellow	1976
White	2200
Bright white	2550
Dazzling white	2730

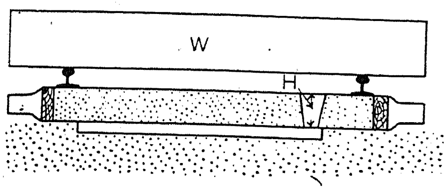
A convenient method of ascertaining the temperature of furnaces is afforded by the use of Segar cones, which are small pyramids of clay, about 3 inches in height and having a ⅝-inch base. These cones are graduated to fuse at temperatures ranging from 1094 to 3470 degrees Fahr., and are numbered from 0.022 to 39. When the fusing point of the cone is reached, the top bends over until it touches the surface on which it rests.

PRESSURE EXERTED BY MOLTEN METAL

WEIGHT REQUIRED ON THE COPE

To find the weight required on a cope to resist the pressure of molten iron, multiply the cope area of the casting in square inches by the height of the riser top above the casting in inches, by 0.21:

$$W = A \cdot H \times 0.21.$$



W = Weight to be placed on a flask in pounds.

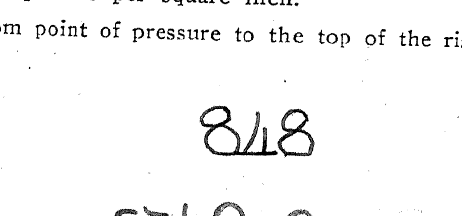
A = Cope area of casting in square inches.

H = Height of riser top above casting in inches.

PRESSURE ON THE MOLD

To find the pressure exerted on a mold by molten iron, multiply the height in inches from the point of pressure to the top of the riser, by 0.26:

$$P = H \times 0.26.$$



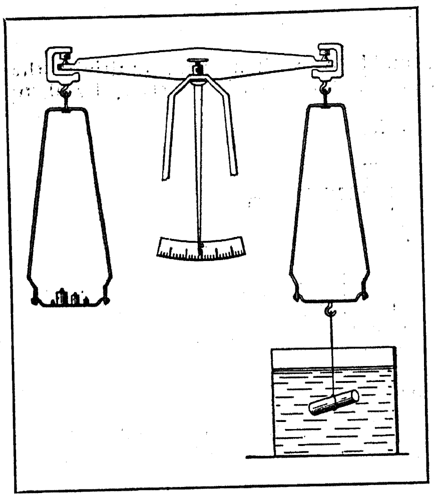
P = Pressure in pounds per square inch.

H = Height from point of pressure to the top of the riser in inches.

NOTES ON SPECIFIC GRAVITY

The *specific gravity* of a substance is its weight compared with the weight of an equal volume of water. According to Archimedes' principle, the difference between the weight of a body in air and the weight of the same body submerged in water, is equal to the weight of the water displaced, or in other words, the weight of an equal volume of water. Therefore, to find the specific gravity, divide the weight of the body in air by the difference between its weight in air and its weight in water, at standard temperature.

There is no general agreement in regard to standard temperature, experimenters using 32 degrees Fahr., 39.1 degrees Fahr., 60 degrees Fahr., and 62 degrees Fahr., but 62 degrees Fahr. is the temperature now most generally used.



The formula for specific gravity is

$$S.\ G. = \frac{W}{W - w}$$

where

W = weight of body in air.

w = weight of body submerged in water.

S. G. = specific gravity.

The illustration shows the method of weighing a submerged body.

NOTES ON SPECIFIC GRAVITY
(Concluded)

To find the specific gravity when weight per cubic inch or weight per cubic foot is given, multiply the weight by the constants given below, corresponding to the temperature at which the specific gravity is required.

Constants (weight per cubic inch given).

Temperature, degrees Fahr.	32	39.1	60	62
Constant	27.6840	27.6809	27.7015	27.7123

Constants (weight per cubic foot given).

Temperature, degrees Fahr.	32	39.1	60	62
Constant	0.016021	0.016019	0.016035	0.016037

To find the weight per cubic inch or weight per cubic foot, when the specific gravity is given, multiply the specific gravity by the constant given below, corresponding to the temperature, which was used as standard.

Constants for weight per cubic inch.

Temperature, degrees Fahr.	32	39.1	60	62
Constant	0.036122	0.036126	0.036090	0.036085

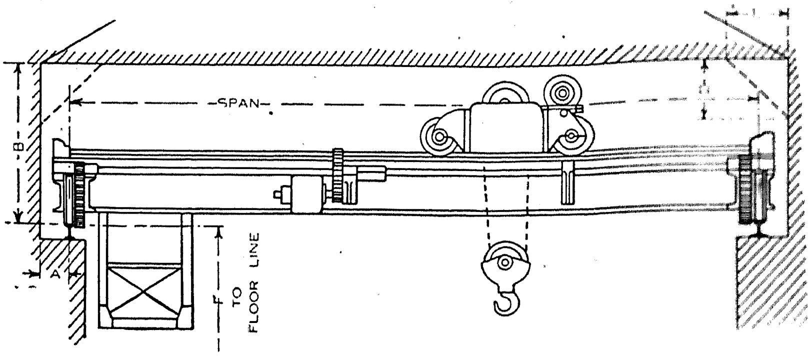
Constants for weight per cubic foot.

Temperature, degrees Fahr	32	39.1	60	62
Constant	62.418	62.425	62.364	62.355

To find the specific gravity at 62 degrees Fahr. when the specific gravity at one of the above temperatures is given, multiply the given specific gravity by one of the following constants:

Temperature, degrees Fahr.	32	39.1	60
Constant	1.00101	1.00122	1.00014

CLEARANCES FOR ELECTRIC CRANES



THE FOLLOWING DIMENSIONS OF A AND B SHOULD BE ALLOWED IN NEW BUILDINGS

	3 tons	5 tons	10 tons	15 tons	20 tons	25 tons	30 tons	40 tons	50 tons	60 tons	75 tons	100 tons	150 tons
Cleveland Crane & Engineering Co:—													
A	..	8	8	10	11	11	11	12	12	..	..	14	..
B	..	66	77	80	86	90	95	99	102	..	..	120	..
Euclid Crane & Hoist Co.:—													
A	6	7	8	8	..	..	..	..	..	..	..	..	..
B	48	51	54	57	..	..	..	..	..	..	..	..	..
Maris Brothers:—													
A	..	6	6½	7	7	7½	..	..	..	..	..	..	..
B	..	54	65	74	76	96	..	..	..	..	..	..	..
Morgan Engineering Co. (1):—													
A	..	9	9½	9½	11	11	11½	12½	12½	..	..	15	..
B	..	69	81	81	87	87	90	99	102	..	..	135	..
Northern Engineering Works (2):—													
A	8	8	9¾	9¾	9¾	10½	10½	12	14	..	..	14	..
	to	to	to	to	to	to	to					to	
	9½	9½	10½	10½	10½	11	12	..	..	..	..	17	..
B	63	63	65	69	84	87	109	109	111	..	..	117	..
	to	to	to	to	to	to							
	69	69	77	83	101	103	..	..	..	..	..	..	..
Pawling & Harnischfeger Co. (3):—													
A	..	9	10	10	10	11	12	13	15	16	14½	18½	19
		to			to	to							
	..	10	..	..	11	12	..	..	..	..	..	..	..
B	..	56¼	61¼	67¼	68¼	75¼	78¾	91½	98½	106¼	138	161¼	189¼
		to	to	to	to	to							
	..	59½	62½	68½	69½	77½	..	..	..	..	..	..	..
Shepard Electric Crane & Hoist Co.:—													
A	..	6½	7½	8½	8½	10½	10½	12½	15	..	15	..	..
B	..	52	62	62	79	79	87	103	103	..	125	..	..
Toledo Bridge & Crane Co.:—													
A	..	7	8	8½	8½	8½	9	9	10	..	..	13	..
B	..	57	66	76	76	84	84	108	108	..	..	120	..
Whiting Corp.:—													
A	..	5¼	6½	6½	7½	7½	8	8½	9	..	..	10	..
B	..	54	60	70	70	87	94	99	99	..	..	120	..

Numbers in parenthesis, thus (1), refer to notes on page 33.

CLEARANCES FOR ELECTRIC CRANES
(*Concluded*)

Notes on Clearance Table.

(1) Dimensions A and B are based on cranes with a span of 60 feet.

(2) Dimensions vary with span.

(3) Dimensions vary with span. This firm also lists another 60-ton crane with $A = 14\frac{1}{2}$ inches and $B = 114\frac{1}{4}$ inches.

Information Required in Ordering Cranes

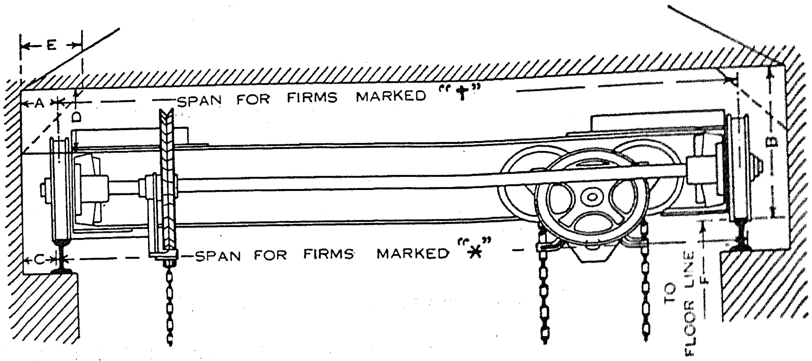
All manufacturers build cranes with dimensions smaller than those given in the table, when required.

When making inquiries about cranes, the following particulars should be given:

Load—Maximum load in net tons to be lifted.
Speed—If special speed for any function is required.
Span—Span in feet from center line to center line of rails.
A—End clearance.
B—Overhead clearance.
D and E—Required if there are roof braces, which interfere with end travel of trolley.
F—Distance from top of runway rail to floor.
Voltage—Voltage of circuit used.
Style—Type of crane preferred.

Size of runway rail and lift of hook are also required if, for any reason, they must be some special size.

CLEARANCES FOR HAND POWER CRANES



THE FOLLOWING CLEARANCES FOR A AND B OR C AND B IN INCHES, SHOULD BE ALLOWED IN NEW BUILDINGS

Firms:— Tons		1	2	3	5	10	15	20	25	30	40	50
†Cleveland Crane & Engrg. Co.	A	..	..	..	5½	6	6	7	7	8	8	9
	B	..	..	..	48	54	63	69	72	78	84	90
*Curtis Pneumatic Machinery Co. (1)	C	3⅛	3⅛	3⅛	3⅛	3⅛	..	..	..	..	..	..
	B	20	20	22	36	42	..	..	..	..	..	..
†Euclid Crane & Hoist Co. (5)	A	4	5	5	6	6	8	8	9	9	..	..
	B	16	18	20	22	53	63	63	69	69	..	..
†Maris Brothers (2)	A	..	..	..	3¾	4½	4½	7	7½	..	..	..
	B	..	..	..	29 to 39	40 to 51	45 to 57	76	96	..	..	..
†Northern Engineering Works (2)	A	..	..	7½ to 9¼	8 to 9¼	8 to 9¼	9¾ to 10	9¾ to 10	9¾ to 10	10½	10½	..
†Northern Engineering Works (2)	B	..	..	31 to 34	34 to 45	41 to 48	43 to 48	45 to 51	45 to 57	63	69	..
†Toledo Bridge & Crane Co. (3)	A	..	..	..	5	6	7	7	8	8	9	9
	B	..	..	..	36	42	42	48	66	72	84	96
†Whiting Corp.	A	..	..	..	6	7	7	7	7	7	8	8½
	B	..	..	..	51	54	57	58	62	76	76	79
*Vulcan Engineering Sales Co. (4)	C	4⅜	4⅜	4⅜	6⅛	..	..	..	..	..	..	..
	B	24	24	24	26½	..	..	..	..	..	..	..

Numbers in parenthesis, thus (1), refer to notes on page 35.

CLEARANCES FOR HAND POWER CRANES
(Concluded)

NOTES ON CLEARANCE TABLE

(1) Clearances are for ordinary geared trolley, with a bar and link suspension, from which can be hung either air hoist or chain block.

Single I-beam crane for 1, 2 and 3 tons.

Double I-beam crane for 5 and 10 tons.

(2) Dimensions vary according to span.

(3) Dimensions are based on standard double beam girders and chain block trolleys from 5 to 20 tons, inclusive. Over 20 tons, on drum type trolleys.

(4) Based on single beam cranes.

(5) Above 5 tons, double beam girders are used, with trolley running on top of the girders.

INFORMATION REQUIRED IN ORDERING CRANES

All manufacturers build cranes with dimensions smaller than those given in the table, when required.

When making inquiries about cranes, the following particulars should be given:

Load—Maximum load in net tons to be lifted.
Speed—If special speed for any function is required.
Style—Type of crane preferred.
Span—Span in feet.
A or C—End of clearance.
D and E—Required if there are roof braces, which interfere with end travel of trolley.
F—Distance from top of runway rail to floor.

Span is from center line to center line of rails for firm marked "*", otherwise it is from outside to outside of rails.

STRENGTH OF CHAINS AND ROPES

STRENGTH OF CRANE CHAINS

Diameter of Link, inches	Ultimate Strength of Chain in Pounds Per Square Inch	Safe Working Load in Pounds
1/4	3,360	840
5/16	5,040	1,260
3/8	7,280	1820
7/16	10,080	2,520
1/2	13,440	3,360
5/8	20,720	5,180
1	53,760	13,440
1 1/4	84,000	21,000
1 1/2	120,960	30,240

In the above table the safe working load is given with 4 as a factor of safety. In some cases a factor of safety of 6 is used, and can be obtained by dividing the ultimate strength by 6. Chains should be frequently examined, and occasionally annealed to prevent crystallization. As the links wear, the strength of the chain is correspondingly reduced.

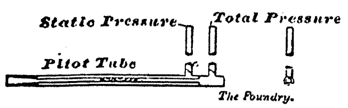
THE STRENGTH OF MANILA ROPE

Manila rope is measured by circumference instead of diameter, therefore, a 3-inch rope is nearly 1 inch in diameter. The strength depends upon the quality of the fibre, and the solidity with which the rope is twisted. A 3-inch rope, soft laid, has a maximum strength of about 7,300 pounds, while a hard laid rope will withstand up to 9,000 pounds. The breaking strength of ropes can be obtained approximately by multiplying the square of the circumference by 8 and the product by 100, which gives the strength in pounds. For blocks and falls, the rope should be figured at one-eighth its breaking strength, using two double blocks of suitable size. Thus, if 1,000 pounds is to be raised regularly, two double 8-inch blocks, equipped with 3-inch manila rope, should be used. For direct pulls on single ropes, the latter should be operated at only one-twentieth of its breaking strength, to allow for wear and tear.

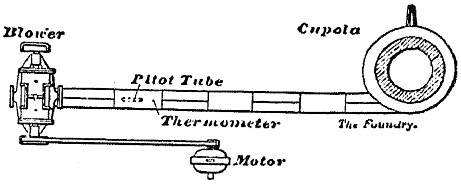
TESTING BLOWERS

MEASUREMENT OF VOLUME, PRESSURE AND HORSEPOWER AT PRESSURE OF ONE TO TEN POUNDS PER SQUARE INCH

Velocity.—The volume of air discharged from an orifice or pipe is, theoretically, equal to the product of the velocity of the air flowing and the area of the orifice. Hence, for the calculation of volume, the velocity is an important factor. To determine the velocity, the Pitot tube is commonly used as shown in the accompanying illustration. It should be inserted in the center of a straight run of blast pipe within about ten feet of the blower. One part of the Pitot tube transmits the total pressure, which is the sum of the static pressure and the velocity pressure. The other part, in communication with the slots shown by dotted lines, transmits the static pressure. Evidently the difference is the velocity pressure. Each is connected to a water gage which should show magnified readings so that the difference may be accurately determined.



Construction of Pitot Tube.



Location of Pitot Tube in Blast Pipe.

Accuracy.—Great care should be exercised in measuring the velocity pressure, and the instruments should be carefully calibrated. In the ordinary blast pipe for conducting air from the blower to the cupola or furnace, the velocity should not exceed two or three thousand feet per minute. As this velocity corresponds to a pressure of only about 0.4 inch of water, the measurement requires care, but with good instruments the readings will be accurate enough for all practical purposes.

Volume.—The velocity pressure being known, the volume of free air passing through the pipe may be determined from the following formula:

$$V = a\,v = \frac{60\,a\,c\,P_1}{P}\sqrt{\frac{2gp}{d}}$$

in which V = the volume of free air in cubic feet per minute,
c = coefficient of Pitot tube, which should be determined for each tube,
a = area of the pipe in square feet,
v = velocity in feet per minute,
$2g$ = 64.32,
p = velocity pressure in pounds per square foot; p is the difference between the two pressures observed on the Pitot tube.
d = density or weight per cubic foot of air at pressure, temperature and humidity at point of observation,
P_1 = absolute pressure of air in the pipe in pounds per square foot,
P = atmospheric pressure in pounds per square foot.

Horsepower.—Assuming that the air is compressed without cooling, the horsepower may be found from the following:

$$H.P. = \frac{VP\left[\left(\frac{P_1}{P}\right)^{1/3} - 1\right]}{11{,}000}$$

in which
V = the volume of free air in cubic feet per minute, as found above,
P = pressure of the atmosphere or suction pressure (absolute in pounds per square foot,
P_1 = pressure of compression (absolute) in pounds per square foot.

Formulas.—Including the preceding, there are four formulas sometimes used in computing the power required.

(1) $H.P. = \dfrac{VP\,l_e\left(\frac{P_1}{P}\right)}{33{,}000}$ (2) $H.P. = \dfrac{VP\left[\left(\frac{P_1}{P}\right)^{1/3} - 1\right]}{11{,}000}$ (3) $H.P = \dfrac{V(P_1 - P)}{33{,}000}$ (4) $H.P = \dfrac{\text{lbs. per sq. in.} \times V}{200}$

Formula No. 1 gives the horsepower required when the air is cooled during compression as in the ordinary air compressor.

Formula No. 2, which has been explained, is used when it may be assumed that the air is compressed so quickly that it does not have time to cool to atmospheric temperature as in nearly all blower work.

Formula No. 3, the ordinary "hydraulic" formula, is ordinarily used for pressures up to five ounces.

Formula No. 4 is frequently used for positive or rotary blowers, for determining the horsepower required for operating these machines. In this formula V = the volume of air displaced by the impellers, no allowance being made for slippage.

METHOD OF CALCULATING MIXTURES FOR THE CUI

ANALYSIS OF THE CASTINGS REQUIRED

	Per
Silicon	1.(
Phosphorus	0.;
Sulphur ....less than	0.1
Manganese	0.5

From previous experience with the iron and coke, due consideration given to local melting conditions, it is estimated that the approximate 1 silicon will be 0.25 per cent, and manganese 0.10 per cent, while the in in sulphur will be approximately 0.03 per cent.

The average analysis of the iron and scrap to be charged should follows:

	Per
Silicon	1.8
Phosphorus	0.:
Sulphur ....less than	0.(
Manganese	0.(

TABULATION OF THE MATERIAL TO BE CHARGED AND METHOD OF FIGURIN MIXTURE

		ANALYSIS				WEIGHT OF*		
KIND OF MATERIAL	Weight in Pounds	Silicon Per Cent	Sulphur Per Cent	Phosphorus Per Cent	Manganese Per Cent	Silicon	Sulphur	Phosphorus
Steel Scrap	400	0.10	0.07	0.10	0.60	0.40	0.28	0.40
Machinery Scrap	2,000	1.70?	0.10?	1.00?	0.60?	34.00	2.00	20.00
High Sulphur Southern	1,600	0.70	0.10	1.50	0.30	11.20	1.60	24.00
X No. 1	1,600	3.00	0.03	0.80	1.25	48.00	0.48	12.80
No. 3 Foundry	4,000	1.75	0.07	0.30	0.60	70.00	2.80	12.00
High Silicon Iron:	800	3.50	0.025	0.07	0.60	28.00	0.20	0.56
Total	10,400					191.60	7.36	69.76
			Average Per Cent			1.84	0.071	0.67

*Multiply the weight of each kind of material by the percent of the element in it, then d total weight of each element by the total weight of the material which in this example is 10,40C

By the relative adjustment of the pig iron and scrap, mixtures for any desired analysis can

GENERAL RULES FOR MIXING IRON BY ANALYSIS

Silicon softens gray iron, opens the grain, lessens density, and, in excess, weakens the metal and causes sponginess.

Sulphur hardens gray iron, closes the grain, increases density, may strengthen, and, in excess, causes gas holes and other defects, and may weaken.

Phosphorus increases the fluidity of gray iron, and in excess, decreases the strength and increases brittleness.

Manganese increases the density of gray iron, it may strengthen, and, in small amounts, up to 0.50 or 0.75 per cent, it softens; in large amounts, it hardens.

To get strong, close grained iron, keep the silicon at the right amount to give from 0.50 to 0.80 per cent combined carbon in the metal; keep the sulphur below 0.12 per cent; keep the phosphorus under 0.50 per cent, and the manganese between 0.60 and 0.90 per cent.

To get soft iron, keep the silicon high; keep the sulphur low; keep the phosphorus under 1 per cent, and keep the manganese between 0.50 and 0.70 per cent.

Relation Between Composition and Thickness of Castings

For the best results the silicon content must bear a close relation to the thickness of the castings. Extremely light castings sometimes contain as high as 3.00 per cent silicon while castings of the heaviest section may contain less than 1.0 per cent silicon.

Cupola Changes

When making mixtures, allowance must be made for the loss and gain of elements in the cupola. While these vary to some extent. they will be approximately as follows:

Silicon, 0.20 to 0.25 per cent loss.
Phosphorus, no change.
Sulpuhr, 0.04 per cent gain.
Manganese, 0.10 to 0.30 per cent loss.

COMPOSITIONS FOR GRAY IRON CASTINGS

Type of Casting	Silicon, Per cent	Sulphur, Per cent	Phosphorus, Per cent	Manganese, Per cent	Combined Carbon, Per cent	Total Carbon, Per cent
Acid-resistant.........	1 to 2	UNDER 0.05	UNDER 0.40	1 to 1.5	HIGH	LOW
Acid stills and eggs....	1 to 1.5	UNDER 0.05	UNDER 0.40	1 to 1.25	HIGH	LOW
Agricultural machinery, ordinary............	2 to 2.50	0.06 to 0.09	0.60 to 0.80	0.50 to 0.80		
Agricultural machinery, very thin...........	2.25 to 2.75	0.06 to 0.08	0.70 to 0.90	0.40 to 0.70		
Air cylinders..........	1 to 1.75	UNDER 0.09	0.15 to 0.30	0.70 to 0.90		
Ammonia cylinders....	1 to 1.75	UNDER 0.09	0.15 to 0.30	0.70 to 0.90		
Annealing boxes for malleable work........	0.50 to 0.80	UNDER 0.10	0.10 to 0.20	0.10 to 0.30	2.60 to 2.90	2.60 to 2.90
Annealing boxes, pots and pans...........	1.40 to 1.60	UNDER 0.06	UNDER 0.20	0.60 to 1		LOW
Automobile castings...	1.75 to 2.25	UNDER 0.08	0.40 to 0.60	0.60 to 0.80		
Automobile cylinders..	1.75 to 2	UNDER 0.08	0.15 to 0.30	0.60 to 0.80	0.55 to 0.65	3 to 3.25
Automobile flywheels..	2.25 to 2.50	UNDER 0.07	0.40 to 0.50	0.50 to 0.70		
Balls for ball mills.....	0.90 to 1.20	UNDER 0.08	0.20	0.60 to 1		LOW
Bedstead work........	2.60 to 2.80	UNDER 0.09	0.90 to 1.10	0.30 to 0.60		
Bed plates............	1.25 to 1.75	UNDER 0.10	0.30 to 0.60	0.60 to 0.80		
Bells and hoppers for blast furnaces.......	1.25 to 1.50	UNDER 0.08	UNDER 0.30	0.80 to 1		LOW
Binders..............	2 to 2.50	0.06 to 0.08	0.60 to 0.80	0.60 to 0.80		
Blast furnace castings	1.25 to 1.75	UNDER 0.09	0.30 to 0.60	0.50 to 0.80		
Boiler fronts..........	2.25 to 2.75	UNDER 0.09	0.50 to 0.70	0.40 to 0.60		
Boiler sections........	2 to 2.50	UNDER 0.08	0.15 to 0.30	0.60 to 1		
Brake shoes...........	1.40 to 1.60	0.08 to 0.10	UNDER 0.50	0.50 to 0.70		LOW
Car castings, gray iron..	1.50 to 2.25	UNDER 0.08	0.40 to 0.60	0.60 to 0.80		
Car wheels, chilled.....	0.60 to 0.70	0.10 to 0.18	0.30 to 0.40	0.50 to 0.60		
Caustic pots..........	1.25 to 1.75	UNDER 0.06	UNDER 0.30	0.60 to 1		2.75 to 3
Chemical castings.....	1 to 2	UNDER 0.06	UNDER 0.40	1 to 1.50		2.75 to 3
Chilled castings.......	0.75 to 1.25	0.08 to 0.10	0.20 to 0.40	0.80 to 1.20		
Chills................	1.75 to 2.25	UNDER 0.07	0.10 to 0.20	0.60 to 0.90		
Collars and couplings for shafting.........	1.75 to 2	UNDER 0.08	0.40 to 0.50	0.50 to 0.70		
Cone pulleys..........	2 to 2.25	UNDER 0.08	0.50 to 0.80	0.50 to 0.70		
Cotton machinery.....	2 to 2.25	UNDER 0.08	0.60 to 0.80	0.50 to 0.80		
Crusher castings.......	1 to 2	UNDER 0.09	UNDER 0.40	0.60 to 0.80		LOW
Crusher jaws..........	0.80 to 1	0.08 to 0.10	0.20 to 0.40	0.80 to 1.20	HIGH	
Cutting tools, chilled iron................	1 to 1.25	UNDER 0.08	0.20 to 0.40	0.60 to 0.80		
Cylinder bushings, locomotive.............	1.25 to 1.50	UNDER 0.08	0.30 to 0.50	0.70 to 0.90		
Cylinders.............	1 to 2	UNDER 0.10	0.30 to 0.60	0.60 to 1		LO[illegible]
Dies for drop hammers.	1.25 to 1.50	UNDER 0.07	UNDER 0.20	0.60 to 0.80		LO[illegible]
Diamond polishing wheels.............	2.50 to 3	UNDER 0.07	0.20 to 0.40	0.30 to 0.50		L[illegible]
Dynamo frames, bases and spiders, large....	2 to 2.50	UNDER 0.08	0.50 to 0.80	0.40 to 0.60		[illegible]

COMPOSITIONS FOR GRAY IRON CASTINGS
(Continued)

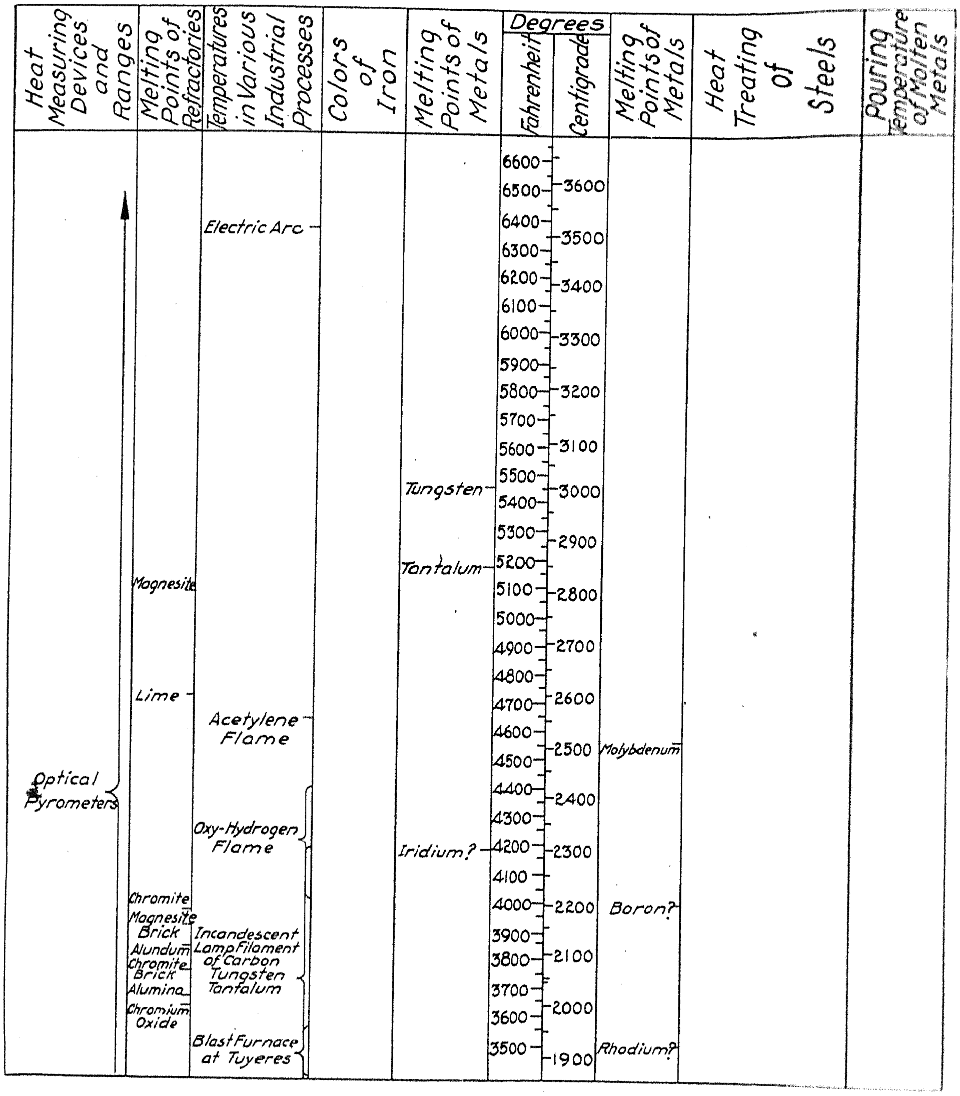
Type of Casting	Silicon, Per cent	Sulphur, Per cent	Phosphorus, Per cent	Manganese, Per cent	Combined Carbon, Per cent	Total Carbon, Per cent
Dynamo frames, bases and spiders, small	2.50 to 3	UNDER 0.08	0.50 to 0.80	0.40 to 0.60		
Electrical	2 to 3	UNDER 0.08	0.50 to 0.80	0.40 to 0.60		LOW
Eccentric straps	1.75 to 2	UNDER 0.09	0.40 to 0.60	0.60 to 0.80		
Embossing heads	1.25 to 1.50	UNDER 0.09	0.30 to 0.50	0.70 to 1		
Engine frames	1.25 to 2	UNDER 0.10	0.30 to 0.50	0.60 to 1		
Fan and blower casings	2 to 2.50	UNDER 0.08	0.60 to 0.80	0.40 to 0.60		
Ferrocyanide pots	3 to 4	UNDER 0.08	0.40 to 0.80	0.40 to 0.80		
Flywheels	1.50 to 2.25	UNDER 0.08	0.40 to 0.60	0.50 to 0.70		
Friction clutches	1.75 to 2	0.08 to 0.10	UNDER 0.30	0.50 to 0.70		LOW
Gas engine cylinders	1 to 1.75	UNDER 0.08	0.15 to 0.30	0.70 to 0.90		3 to 3.3
Gears, heavy	1 to 1.5	0.08 to 0.10	0.30 to 0.50	0.80 to 1		LOW
Gears, medium	1.50 to 2	UNDER 0.09	0.40 to 0.60	0.70 to 0.90		
Gears, small	2 to 2.50	UNDER 0.08	0.50 to 0.70	0.60 to 0.80		
Grate bars	1.25 to 1.75	UNDER 0.06	UNDER 0.20	0.60 to 0.80		LOW
Grinding burrs	0.60 to 0.90	UNDER 0.12	0.20 to 0.40	0.40 to 0.60		
Gun carriages	1 to 1.25	UNDER 0.06	0.20 to 0.30	0.80 to 1		
Hangers for shafting	1.50 to 2	UNDER 0.09	0.40 to 0.60	0.60 to 0.80		
Hardening pots	0.60 to 1	UNDER 0.06	UNDER 0.20	0.40 to 0.60		
Hardware, light	2.25 to 2.75	UNDER 0.08	0.60 to 0.90	0.40 to 0.60		
Heat-resistant iron	1.25 to 2.50	UNDER 0.10	UNDER 0.20	0.60 to 1		LOW
Hollow ware	2.25 to 2.75	UNDER 0.08	0.60 to 0.90	0.40 to 0.60		
Housings for rolling mills	1 to 1.25	UNDER 0.10	UNDER 0.30	0.80 to 1		
Hydraulic cylinders, heavy	0.80 to 1.20	0.10 to 0.12	0.20 to 0.40	0.80 to 1		LOW
Hydraulic cylinders, medium	1.20 to 1.60	0.09 to 0.11	0.30 to 0.50	0.70 to 0.90		LOW
Ingot molds and stools	1.25 to 1.50	UNDER 0.06	UNDER 0.20	0.60 to 1		
Locomotive castings, heavy	1.25 to 1.50	UNDER 0.10	0.30 to 0.50	0.70 to 0.90		
Locomotive castings, light	1.50 to 2	UNDER 0.09	0.40 to 0.60	0.60 to 0.80		
Locomotive cylinders	1 to 1.50	0.08 to 0.10	0.30 to 0.50	0.80 to 1		
Locks and hinges	2.50 to 2.75	UNDER 0.08	0.70 to 1	0.40 to 0.60		
Machinery castings, heavy	1 to 1.50	UNDER 0.10	0.30 to 0.50	0.70 to 0.90		LOW
Machinery castings, medium	1.50 to 2	UNDER 0.09	0.40 to 0.60	0.60 to 0.80		
Machinery castings, light	2 to 2.50	UNDER 0.08	0.50 to 0.70	0.50 to 0.70		
Mine-car wheels	0.75 to 1.25	UNDER 0.10	0.30 to 0.50	0.40 to 0.60		
Motor frames, bases and spiders, large	2 to 2.50	UNDER 0.08	0.50 to 0.80	0.40 to 0.60		LOW
Motor frames, bases and spiders, small	2.50 to 3	UNDER 0.08	0.50 to 0.80	0.30 to 0.40		LOW
Mowers	2 to 2.50	UNDER 0.09	0.60 to 0.80	0.50 to 0.80		

COMPOSITIONS FOR GRAY IRON CASTINGS
(Concluded)

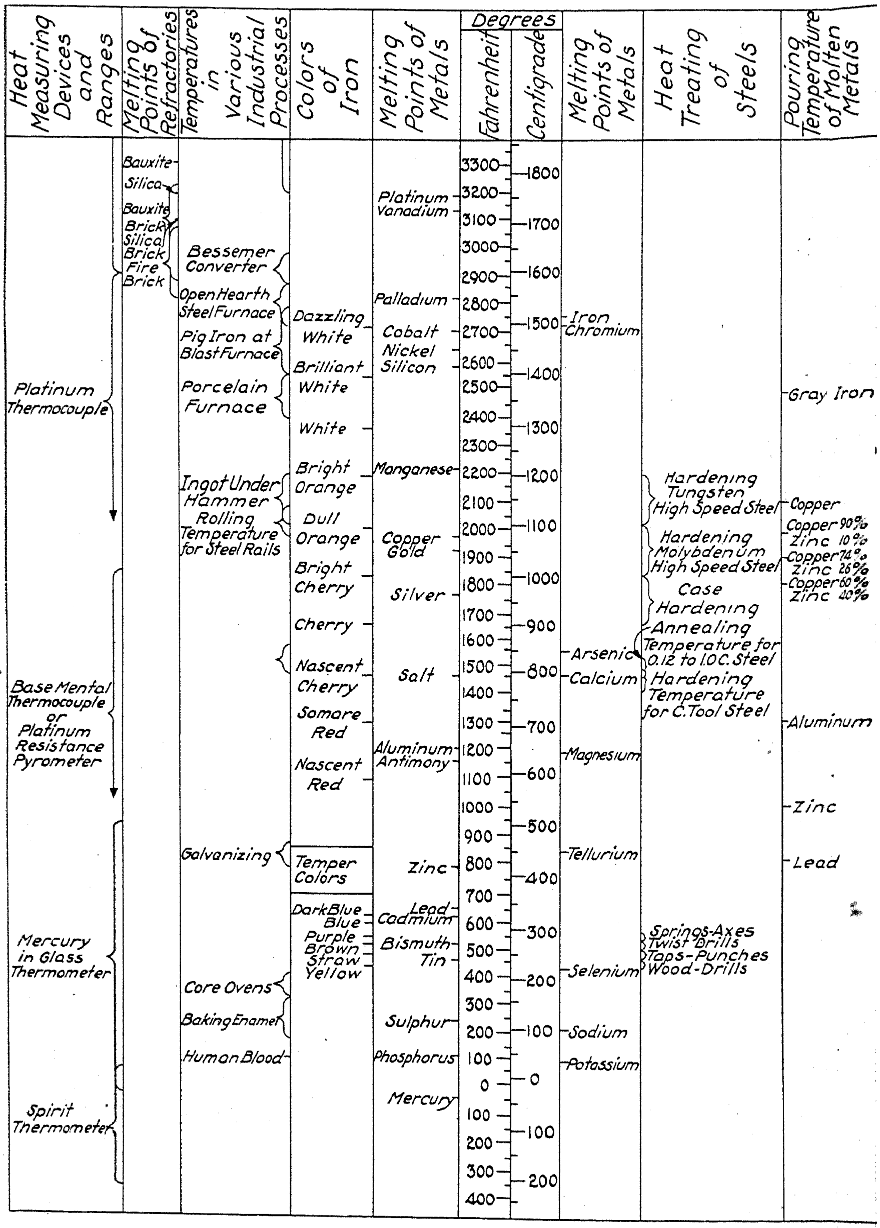
Type of Castings	Silicon, Per cent	Sulphur, Per cent	Phosphorus, Per cent	Manganese, Per cent	Combined Carbon, Per cent	Total Carbon, Per cent
Novelty work	2.50 to 3	UNDER 0.08	0.80 to 1	0.40 to 0.60		
Nitre pots	1 to 1.50	UNDER 0.06	UNDER 0.20	1 to 1.50		LOW
Ornamental	2.25 to 2.75	UNDER 0.09	0.70 to 1	0.40 to 0.60		
Permanent molds	2 to 2.25	UNDER 0.07	0.20 to 0.40	0.60 to 0.90		
Permanent mold castings	1.50 to 3	UNDER 0.06	0.30 to 0.80	UNDER 0.40		
Piano plates	2 to 2.25	UNDER 0.08	0.40 to 0.60	0.60 to 0.80		
Pillow blocks	1.50 to 1.75	UNDER 0.10	0.40 to 0.60	0.60 to 0.80		
Pipe	1.50 to 2	UNDER 0.10	0.50 to 0.60	0.60 to 0.80		
Pipe fittings	1.75 to 2.50	UNDER 0.08	0.50 to 0.80	0.60 to 0.80		
Pipe fittings for superheated steam lines	1.50 to 1.75	UNDER 0.08	0.20 to 0.40	0.70 to 0.90		LOW
Piston rings	2.00 to 2.50	UNDER 0.12	0.40 to 0.90	0.40 to 0.60		LOW
Plow points, chilled	0.75 to 1.25	UNDER 0.09	0.20 to 0.30	0.80 to 1		
Plugs for piercing billets	1 to 1.25	UNDER 0.08	0.20 to 0.30	0.40 to 0.60		
Printing press	1.75 to 2.25	UNDER 0.09	0.50 to 0.70	0.50 to 0.70		
Propeller wheels	1 to 1.75	UNDER 0.10	0.20 to 0.40	0.60 to 1		
Pulleys, large	1.75 to 2.25	UNDER 0.09	0.50 to 0.70	0.60 to 0.80		
Pulleys, small	2.25 to 2.75	UNDER 0.08	0.60 to 0.90	0.50 to 0.70		
Pumps, hand	2 to 2.25	UNDER 0.08	0.60 to 0.80	0.50 to 0.70		
Radiators	2 to 2.25	UNDER 0.08	0.40 to 0.60	0.50 to 0.70		
Railroad castings	1.50 to 2.25	UNDER 0.10	0.40 to 0.60	0.60 to 0.80		
Retorts	1.75 to 2	UNDER 0.06	UNDER 0.20	0.60 to 1		LOW
Rolls, chilled	0.60 to 0.80	0.06 to 0.08	0.20 to 0.40	1 to 1.20		
Scales, castings for	2 to 2.50	UNDER 0.08	0.60 to 1	0.50 to 0.70		
Slag car bowls	1.50 to 1.75	UNDER 0.07	UNDER 0.20	0.60 to 1		LOW
Smoke stacks, locomotive	1.75 to 2	UNDER 0.10	0.30 to 0.60	0.60 to 0.80		
Soil pipe and fittings	1.75 to 2.25	UNDER 0.10	0.50 to 0.80	0.50 to 0.80		
Steam cylinders, heavy	1 to 1.25	UNDER 0.10	0.20 to 0.40	0.80 to 1		LOW
Steam cylinders, medium	1.25 to 1.75	UNDER 0.09	0.30 to 0.50	0.70 to 0.90		
Stove plates	2.25 to 2.75	UNDER 0.08	0.60 to 0.90	0.50 to 0.80		
Toys	2 50 to 3	UNDER 0.08	0.80 to 1	0.40 to 0.60		
Typewriter castings	2.50 to 2.75	UNDER 0.08	0.60 to 0.80	0.50 to 0.60		
Valves, large	1.25 to 1.75	UNDER 0.08	0.20 to 0.40	0.80 to 1		
Valves, small	1.75 to 2.25	UNDER 0.08	0.40 to 0.60	0.50 to 0.70		
Water heaters	2 to 2.25	UNDER 0.08	0.30 to 0.50	0.50 to 0.70		
Weaving machinery	2 to 2.25	UNDER 0.09	0.50 to 0.80	0.50 to 0.70		
Wheels, large	1.50 to 2	UNDER 0.09	0.30 to 0.50	0.60 to 0.80		
Wheels, small	1.75 to 2.25	UNDER 0.08	0.40 to 0.60	0.50 to 0.70		
Wheel centers	1.25 to 1.50	UNDER 0.10	0.30 to 0.50	0.70 to 0.90		
White iron castings	0.50 to 1	0.08 to 0.10	0.30 to 0.60	0.40 to 0.60		
Woodworking machinery	1.75 to 2.25	UNDER 0.09	0.50 to 0.70	0.50 to 0.70		

METALLURGICAL TEMPERATURE CHART

This scale with the one on page 44 forms a continuous chart of metallurgical phenomena from 400 to 6600 degrees Fahr. Both Fahrenheit and Centigrade scales are presented, together with the melting points of metals, heat treating data and other information.

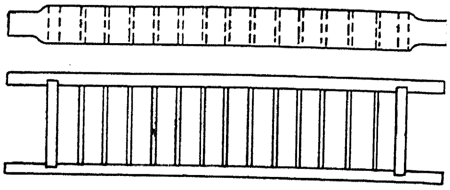


METALLURGICAL TEMPERATUE CHART
(Concluded)



FORMULAS FOR FINDING WEIGHTS

Finding Weight of Body of Sand



$W = L\ B\ H \times 87.$

W = Weight of body of sand in pounds.

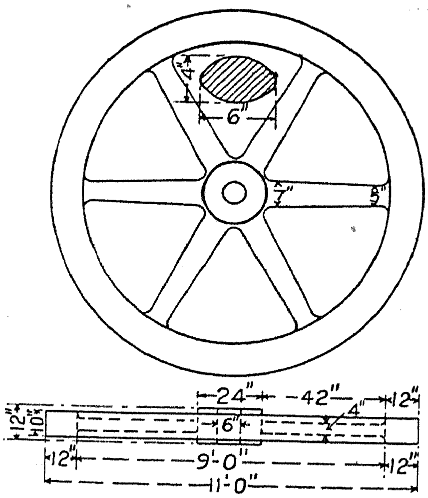
L = Length of body of sand in feet.

B = Breadth of body of sand in feet.

H = Height of body of sand in feet.

Finding Weight of Fly Wheel

To find the weight of a flywheel, 11 feet in diameter, having elliptical arms. The first operation is to find the weight of the hub; second, the rim; and third, the arms. The sum of these gives the weight of the wheel.



To find the weight of the hub:

$$W=(d+T)TL\times 0.817$$

To find the weight of the rim, the same formula as above is used, considering it a cylinder, 10 inches long and 12 inches thick.

To find the weight of one arm:

$$W=DdL\times 0.24$$

Multiply by six to find the weight of the six arms.

W=Weight of casting in pounds.

D=Outside or large diameter in inches.

d=Inside or small diameter in inches.

L=Length in inches.

T=Thickness in inches.

B=Breadth in inches.

MEASURING THE CAPACITY OF LADLES

DIAMETER OF LADLE AT THE BOTTOM IN INCHES.

Iron in ladle, inches.	20	20½	21	21½	22	22½	23	23½	24	24½	25	26	27	28	29
1	78	82	86	90	95	99	104	109	113	118	123	133	143	154	165
2	157	165	173	181	191	199	209	219	227	237	247	267	287	309	332
3	237	249	261	273	288	300	315	330	342	357	372	402	433	466	500
4	318	334	350	366	386	402	422	442	459	479	498	538	580	624	670
5	400	420	440	461	485	506	530	555	577	602	626	676	728	784	841
6	483	507	531	557	585	611	639	669	696	726	755	815	877	945	1,014
7	567	595	623	654	686	717	749	784	816	851	885	955	1,028	1,108	1,188
8	652	684	716	752	788	824	860	901	938	977	1,016	1,096	1,180	1,272	1,364
9	738	774	811	851	892	932	972	1,019	1,061	1,105	1,149	1,239	1,334	1,437	1,541
10	825	865	907	951	997	1,041	1,085	1,138	1,185	1,234	1,289	1,383	1,489	1,604	1,720
11	913	957	1,004	1,052	1,103	1,157	1,199	1,258	1,310	1,364	1,418	1,529	1,646	1,772	1,900
12	1,002	1,050	1,102	1,154	1,210	1,262	1,314	1,380	1,436	1,495	1,554	1,676	1,804	1,942	2,081
13	1,092	1,145	1,201	1,258	1,318	1,374	1,431	1,503	1,564	1,628	1,692	1,824	1,964	2,113	2,264
14	1,183	1,241	1,301	1,363	1,427	1,487	1,549	1,627	1,693	1,762	1,831	1,973	2,125	2,286	2,448
15	1,275	1,338	1,402	1,469	1,537	1,601	1,668	1,752	1,823	1,897	1,971	2,124	2,288	2,460	2,634
16	1,368	1,436	1,504	1,576	1,648	1,716	1,788	1,878	1,954	2,033	2,112	2,276	2,452	2,636	2,821
17	1,462	1,535	1,608	1,684	1,760	1,833	1,910	2,006	2,087	2,171	2,255	2,430	2,617	2,813	3,010
18	1,557	1,635	1,713	1,793	1,873	1,957	2,033	2,135	2,221	2,310	2,399	2,585	2,784	2,992	3,200
19	1,653	1,736	1,819	1,903	1,987	2,071	2,157	2,265	2,356	2,450	2,545	2,742	2,952	3,172	3,392
20	1,749	1,838	1,926	2,014	2,102	2,190	2,282	2,396	2,492	2,591	2,692	2,900	3,122	3,353	3,585
21	1,846	1,942	2,034	2,126	2,219	2,312	2,408	2,529	2,630	2,734	2,841	3,060	3,293	3,536	3,780
22	1,946	2,047	2,143	2,239	2,337	2,435	2,535	2,663	2,769	2,878	2,991	[illegible]	3,466	3,720	3,976
23	2,047	2,153	2,253	2,353	2,456	2,559	2,663	2,798	2,909	3,024	3,142	3,384	3,640	3,906	4,174
24	2,149	2,261	2,364	2,468	2,576	2,684	2,792	2,934	3,050	3,171	3,294	3,548	3,816	4,093	4,373
25	2,251	2,370	2,475	2,583	2,698	2,810	2,922	3,072	3,193	3,320	3,448	3,713	3,993	4,282	4,574
26	.....	.....	2,587	2,699	2,821	2,936	3,053	3,211	3,337	3,470	3,603	3,880	4,172	4,472	4,776
27	.....	.....	.....	.....	2,949	3,053	3,184	3,354	3,483	3,621	3,760	4,048	4,352	4,664	4,980
28	.....	.....	.....	.....	.....	.....	3,316	3,498	3,630	3,773	3,918	4,218	4,533	4,807	5,185
29	.....	.....	.....	.....	.....	.....	.....	.....	3,774	3,927	4,078	4,389	4,716	5,052	5,392
30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4,239	4,560	4,900	5,248	5,601
31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4,733	5,086	5,446	5,812
32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5,273	5,645	6,024
33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5,806	6,236
34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6,450
35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
37	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
41	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Iron in ladle, inches.	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1	177	189	201	214	227	240	254	269	283	299	314	330	346	363	380	397
2	356	379	403	429	455	482	510	540	568	600	630	662	694	728	762	796
3	536	571	607	646	685	725	767	813	855	903	948	996	1,044	1,095	1,146	1,197
4	717	764	812	865	917	970	1,026	1,087	1,144	1,208	1,268	1,332	1,396	1,454	1,532	1,600
5	900	959	1,019	1,086	1,150	1,217	1,287	1,363	1,435	1,515	1,590	1,670	1,750	1,835	1,920	2,006
6	1,084	1,155	1,228	1,308	1,385	1,466	1,550	1,641	1,728	1,824	1,914	2,010	2,106	2,208	2,310	2,414
7	1,270	1,353	1,439	1,532	1,622	1,717	1,815	1,921	2,033	2,134	2,240	2,352	2,464	2,583	2,702	2,824
8	1,457	1,552	1,651	1,756	1,860	1,969	2,085	2,203	2,330	2,446	2,568	2,696	2,824	2,960	3,096	3,236
9	1,646	1,753	1,865	1,984	2,100	2,223	2,354	2,486	2,629	2,760	2,898	3,042	3,187	3,340	3,493	3,651
10	1,836	1,955	2,080	2,212	2,342	2,479	2,625	2,771	2,930	3,076	3,230	3,390	3,552	3,722	3,892	4,068
11	2,028	2,159	2,297	2,442	2,585	2,736	2,898	3,058	3,233	3,394	3,564	3,740	3,919	4,106	4,293	4,487
12	2,221	2,364	2,516	2,674	2,830	2,995	3,172	3,347	3,538	3,714	3,900	4,092	4,288	4,494	4,696	4,908
13	2,416	2,571	2,737	2,907	3,077	3,256	3,448	3,638	3,845	4,036	4,238	4,446	4,659	4,882	5,102	5,332
14	2,612	2,779	2,959	3,142	3,326	3,519	3,726	3,931	4,154	4,360	4,578	4,802	5,032	5,272	5,510	5,758
15	2,810	2,990	3,183	3,379	3,577	3,784	4,006	4,226	4,464	4,686	4,920	5,160	5,407	5,654	5,920	6,186
16	3,009	3,202	3,408	3,617	3,829	4,051	4,288	4,523	4,776	5,014	5,264	5,520	5,784	6,058	6,332	6,616
17	3,210	3,416	3,635	3,857	4,083	4,310	4,571	4,822	5,090	5,344	5,610	5,883	6,164	6,455	6,747	7,049
18	3,412	3,631	3,863	4,099	4,339	4,581	4,856	5,123	5,406	5,676	5,958	6,248	6,546	6,854	7,154	7,484
19	3,616	3,848	4,093	4,342	4,596	4,854	5,143	5,426	5,724	6,010	6,308	6,615	6,930	7,255	7,573	7,921
20	3,821	4,067	4,325	4,587	4,855	5,128	5,432	5,731	6,044	6,346	6,660	6,984	7,316	7,658	7,994	8,360
21	4,028	4,288	4,558	4,834	5,116	5,404	5,723	6,038	6,366	6,684	7,014	7,355	7,704	8,064	8,418	8,802
22	4,237	4,510	4,793	5,083	5,379	5,682	6,016	6,347	6,690	7,024	7,370	7,728	8,094	8,472	8,844	9,248
23	4,448	4,734	5,030	5,334	5,644	5,962	6,311	6,657	7,016	7,366	7,728	8,103	8,486	8,882	9,272	9,696
24	4,660	4,959	5,268	5,596	5,911	6,244	6,608	6,969	7,344	7,710	8,088	8,480	8,880	9,294	9,702	10,146
25	4,874	5,186	5,508	5,840	6,180	6,527	6,907	7,283	7,674	8,056	8,451	8,860	9,277	9,709	10,135	10,598
26	5,089	5,414	5,750	6,096	6,451	6,812	7,208	7,599	8,006	8,404	8,816	9,242	9,676	10,126	10,570	11,054
27	5,306	5,644	5,993	6,353	6,724	7,099	7,511	7,917	8,340	8,754	9,183	9,626	10,077	10,545	11,007	11,512
28	5,525	5,876	6,238	6,612	6,998	7,388	7,816	8,237	8,676	9,106	9,552	10,012	10,480	10,966	11,446	11,973
29	5,746	6,109	6,485	6,873	7,274	7,679	8,123	8,559	9,014	9,460	9,923	10,400	10,886	11,390	11,888	12,436
30	5,968	6,344	6,734	7,136	7,552	7,972	8,432	8,883	9,354	9,816	10,296	10,790	11,294	11,816	12,334	12,902
31	6,192	6,581	6,985	7,401	7,832	8,267	8,742	9,209	9,696	10,174	10,671	11,182	11,704	12,244	12,782	13,370
32	6,417	6,819	7,237	7,668	8,114	8,564	9,054	9,537	10,040	10,534	11,048	11,576	12,116	12,674	13,232	13,841
33	6,644	7,059	7,491	7,937	8,397	8,863	9,378	9,867	10,386	10,897	11,428	11,973	12,531	13,107	13,684	14,314
34	6,871	7,301	7,747	8,208	8,682	9,164	9,694	10,199	10,734	11,262	11,810	12,372	12,948	13,542	14,140	14,790
35	7,099	7,543	8,004	8,481	8,969	9,467	10,012	10,533	11,084	11,629	12,194	12,773	13,367	13,979	14,598	15,268
36	7,329	7,786	8,261	8,755	9,258	9,772	10,332	10,869	11,436	11,998	12,580	13,176	13,788	14,418	15,059	15,649
37	.....	8,031	8,520	9,029	9,549	10,079	10,654	11,207	11,790	12,369	12,968	13,582	14,212	14,860	15,522	16,032
38	.....	.....	8,781	9,306	9,840	10,388	10,978	11,547	12,146	12,742	13,358	13,990	14,638	15,306	15,988	16,518
39	.....	.....	.....	9,684	10,133	10,697	11,304	11,889	12,504	13,117	13,750	14,400	15,066	15,754	16,456	16,996
40	.....	.....	.....	.....	10,428	11,007	11,630	12,233	12,864	13,488	14,144	14,812	15,496	16,204	16,927	17,487
41	.....	.....	.....	.....	.....	11,319	11,958	12,577	13,227	13,868	14,541	15,227	15,929	16,656	17,400	17,980
42	.....	.....	.....	.....	.....	.....	12,288	12,923	13,590	14,250	14,940	15,664	16,364	17,110	17,876	18,476
43	.....	.....	.....	.....	.....	.....	.....	13,271	13,955	14,632	15,341	16,053	16,801	17,566	18,354	18,974
44	.....	.....	.....	.....	.....	.....	.....	.....	14,322	15,016	15,742	16,484	17,240	18,024	18,835	19,475
45	.....	.....	.....	.....	.....	.....	.....	.....	.....	15,402	16,145	16,905	17,680	18,485	19,318	19,978
46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16,550	17,349	18,122	18,948	19,802	20,484
47	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	16,958	17,775	18,566	19,411	20,290	20,992
48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18,203	19,014	19,817	20,776	21,502
49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19,469	20,285	21,264	22,015
50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	20,755	21,655	22,530
51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	22,148	23,047
52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23,567

TABLE SHOWING THE CAPACITY OF LADLES AT EACH INCH OF THEIR DEPTH FOR LADLES FROM 10,000 TO 25,000 POUNDS CAPACITY—TABLE IS BASED ON A TAPER OF 1½ INCHES PER FOOT

MEASURING THE CAPACITY OF LADLES

(Concluded)

The accompanying tables are based on a taper in all the different size ladles of 1½ inches to the foot. However, a ladle might differ from this taper considerably without materially affecting the results.

The dimensions given in the table are all in inches, and the sizes of ladles are based on their diameter inside the lining at the bottom. The lining of a ladle thickens with use, and when this thickening is sufficient to affect the results new measurements should be taken, and the column in the table corresponding to its new diameter must be used. Allowance must also be made if the bottom thickens.

The gage which is used in connection with this table, and the method of using same is shown in Fig. 2. The gage consists of a holder as shown in Fig. 1, and a bar of iron to fit the same with graduations 1 inch apart, each graduation being stamped with the capacity of the ladle at the corresponding depth. The sketch shows the gage for an 8,000-pound ladle. As will be seen, the same holder will do for all ladles, but a different bar should be provided for each ladle. This, however, is not absolutely necessary, for if a bar is provided long enough to suit the deepest ladle, it can be used on the smaller sizes as well by obtaining from the table the number of inches of iron it is desired to take, and setting the gage by measurement to suit the same. The sketch makes the method of using very plain. Any shape bar will do for a gage bar, but a flat bar about 1 x ⅛ inch is preferred.

The sketch also shows the holder set at 5,508 pounds of iron. If it is desired to gage this same amount of iron in the same size ladle without using this form of gage, all that is necessary is to turn to the table and find the column for a ladle 32 inches in diameter at the bottom. Then find in this column the figure corresponding to the amount of iron it is desired to take, in this case 5,508 pounds, and look for the corresponding figure in the column denoting how many inches must be taken, which in this case is 25 inches. This depth can then be marked on the inside of the ladle, or can be gaged by any of the methods heretofore described.

	DIAMETER OF LADLE AT THE BOTTOM IN INCHES.									
Iron in ladle, inches.	46	47	48	49	50	51	52	53	54	55
1	415	433	452	471	491	510	531	551	572	594
2	832	868	906	944	984	1,023	1,064	1,104	1,146	1,191
3	1,257	1,305	1,362	1,420	1,480	1,538	1,600	1,660	1,723	1,791
4	1,672	1,744	1,820	1,898	1,978	2,056	2,138	2,218	2,302	2,394
5	2,096	2,186	2,281	2,379	2,479	2,576	2,679	2,779	2,884	2,999
6	2,522	2,632	2,744	2,862	2,982	3,099	3,222	3,343	3,469	3,606
7	2,950	3,080	3,210	3,348	3,488	3,625	3,768	3,909	4,057	4,216
8	3,380	3,530	3,678	3,836	3,996	4,153	4,316	4,478	4,648	4,829
9	3,813	3,982	4,149	4,327	4,506	4,684	4,867	5,050	5,242	5,445
10	4,248	4,436	4,622	4,820	5,019	5,217	5,420	5,624	5,839	6,063
11	4,685	4,892	5,098	5,316	5,534	5,753	5,976	6,201	6,439	6,684
12	5,124	5,350	5,576	5,814	6,052	6,291	6,534	6,780	7,040	7,308
13	5,566	5,811	6,057	6,315	6,572	6,832	7,095	7,352	7,647	7,935
14	6,012	6,274	6,540	6,818	7,095	7,375	7,659	7,947	8,254	8,564
15	6,460	6,740	7,026	7,324	7,621	7,921	8,225	8,535	8,864	9,196
16	6,910	7,208	7,514	7,832	8,149	8,469	8,784	9,126	9,477	9,831
17	7,362	7,679	8,005	8,342	8,680	9,020	9,356	9,720	10,093	10,469
18	7,816	8,152	8,498	8,855	9,213	9,533	9,930	10,317	10,711	11,109
19	8,272	8,628	8,994	9,370	9,749	10,129	10,500	10,917	11,332	11,752
20	8,730	9,106	9,492	9,888	10,287	10,687	11,086	11,520	11,956	12,398
21	9,191	9,587	9,993	10,408	10,828	11,248	11,668	12,125	12,583	13,047
22	9,654	10,070	10,496	10,931	11,371	11,812	12,253	12,732	13,212	13,698
23	10,120	10,556	11,002	11,457	11,917	12,378	12,841	13,342	13,844	14,352
24	10,588	11,044	11,510	11,985	12,465	12,947	13,432	13,955	14,479	15,009
25	11,059	11,535	12,020	12,516	13,016	13,519	14,026	14,571	15,117	15,669
26	11,532	12,028	12,533	13,049	13,569	14,093	14,623	15,189	15,757	16,331
27	12,008	12,524	13,048	13,585	14,125	14,670	15,223	15,810	16,400	16,996
28	12,486	13,022	13,566	14,123	14,683	15,249	15,826	16,434	17,046	17,664
29	12,967	13,523	14,086	14,664	15,244	15,831	16,431	17,051	17,695	18,335
30	13,450	14,026	14,609	15,207	15,808	16,416	17,038	17,680	18,346	19,009
31	13,936	14,532	15,135	15,753	16,374	17,004	17,648	18,312	19,000	19,686
32	14,424	15,040	15,663	16,301	16,943	17,595	18,261	18,947	19,657	20,366
33	14,915	15,550	16,194	16,85[illegible]	17,515	18,189	18,877	19,585	20,317	21,049
34	15,408	16,063	16,727	17,405	18,089	18,786	19,495	20,225	20,979	21,734
35	15,904	16,578	17,263	17,961	18,666	19,386	20,116	20,868	21,644	22,422
36	16,402	17,096	17,801	18,519	19,245	19,989	20,740	21,514	22,312	23,113
37	16,903	17,616	18,342	19,080	19,827	20,594	21,367	22,163	22,983	23,807
38	17,406	18,139	18,885	19,644	20,412	21,201	21,996	22,814	23,657	24,504
39	17,912	18,665	19,431	20,210	21,000	21,811	22,628	23,468	24,334	25,204
40	18,420	19,193	19,999	20,779	21,591	22,424	23,263	24,125	25,014	25,907
41	18,930	19,724	20,530	21,351	22,185	23,040	23,901	24,785	25,697	26,613
42	19,443	20,257	21,083	21,925	22,782	23,650	24,541	25,447	26,382	27,322
43	19,958	20,793	21,639	22,402	23,382	24,271	25,184	26,115	27,070	28,034
44	20,476	21,331	22,197	22,981	23,985	24,895	25,830	26,786	27,761	28,749
45	20,946	21,872	22,758	23,563	24,590	25,522	26,479	27,460	28,455	29,467
46	21,519	22,415	23,322	24,148	25,197	26,151	27,130	28,137	29,152	30,188
47	22,045	22,961	23,888	24,736	25,807	26,783	27,784	28,817	29,853	30,912
48	22,573	23,509	24,557	25,327	26,420	27,418	28,441	29,500	30,555	31,639
49	23,104	24,060	25,129	25,921	27,036	28,056	29,101	30,185	31,261	32,369
50	23,637	24,613	25,703	26,518	27,654	28,696	29,763	30,873	31,920	33,102
51	24,173	25,169	26,280	27,118	28,275	29,339	30,428	31,564	32,682	33,838
52	24,711	25,727	26,859	27,721	28,899	29,983	31,096	32,208	33,397	34,577
53	25,252	26,288	27,441	28,326	29,526	30,634	31,767	32,905	34,115	35,319
54	25,795	26,152	28,032	28,923	30,155	31,283	32,441	33,605	34,836	36,064
55	......	27,418	28,626	29,533	30,787	31,939	33,118	34,308	35,560	36,812
56	......	27,987	29,223	30,146	31,422	32,596	33,798	35,014	36,287	37,563
57	......	......	29,823	30,762	32,050	33,256	34,481	35,723	37,017	38,318
58	......	......	30,426	31,380	32,690	33,918	35,166	36,435	37,750	39,076
59	......	......	......	32,001	33,333	34,583	35,854	37,150	38,486	39,838
60	......	......	......	32,625	33,979	35,251	36,545	37,868	39,225	40,603
61	......	......	......	......	34,628	35,922	37,244	38,589	39,967	41,369
62	......	......	......	......	35,279	36,596	37,941	39,313	40,712	42,139
63	......	......	......	......	......	37,273	38,641	40,040	41,460	42,912
64	......	......	......	......	......	37,953	39,343	40,770	42,211	43,688
65	......	......	......	......	......	......	40,049	41,507	42,966	44,467
66	......	......	......	......	......	......	......	42,312	43,724	45,249
67	......	......	......	......	......	......	......	43,120	44,485	46,034
68	......	......	......	......	......	......	......	......	45,246	46,832
69	......	......	......	......	......	......	......	......	46,011	47,632
70	......	......	......	......	......	......	......	......	......	48,438

TABLE SHOWING THE CAPACITY OF LADLES AT EACH INCH OF THEIR DEPTH, FROM 25,000 TO 45,000 POUNDS CAPACITY.

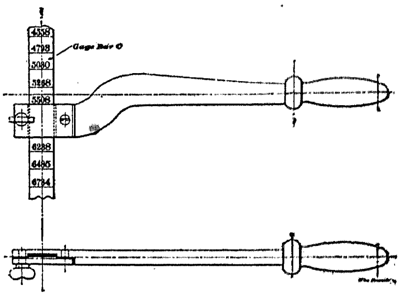


FIG. 1—GAGE BAR.

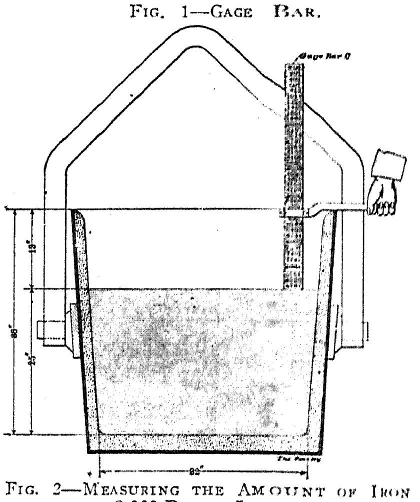


FIG. 2—MEASURING THE AMOUNT OF IRON IN AN 8,000-POUND LADLE WITH A GAGE BAR.

AIR PRESSURE TABLE

This table gives directly the pressure needed to transmit a given quantity of air through a pipe 100 feet long and solves the formula:

$$p^1 = \frac{Lv^2}{2500d} \text{ or } p^1 = \frac{L\left[\dfrac{\text{cu. ft.} \times 144}{60 \times d^2 \times 0.7854}\right]^2}{25000d}$$

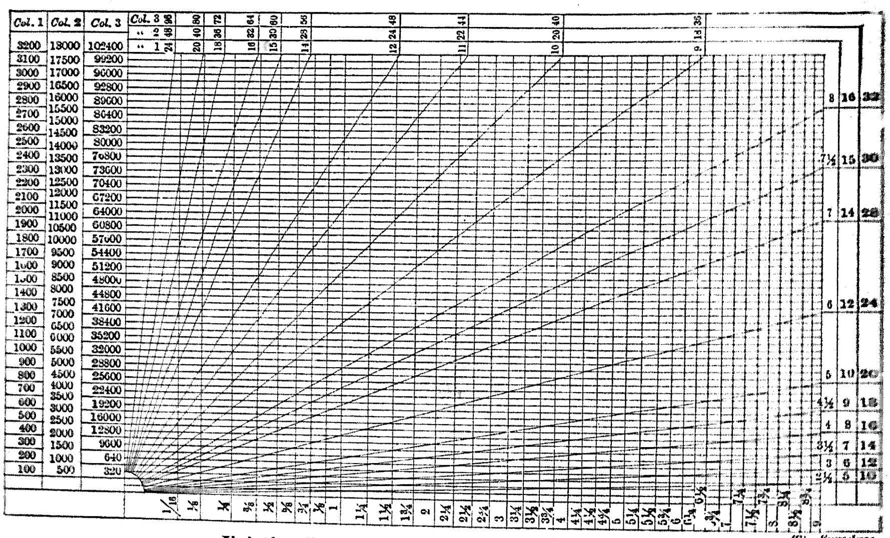
making L=100 feet.
and q=Cubic feet per imnute.
p^1=Ounces per square inch.
d =Diameter pipe in inches.
$q = 5.176\ d\sqrt{p^1}$

For any other length not exceeding 2000 feet, multiply loss by the number of hundred feet of length.

Add for elbows, as follows:

No. pipe diameters in elbow radius......	5	3	2	1½	1¼	1	¾	½
Equivalent feet of straight pipe..........	7.8	8.4	9	10.3	12.7	7.5	35	121

Pipe Diameter in Inches



Friction Loss in ounces, per 100 Ft. of Pipe

AIR VELOCITY TABLE

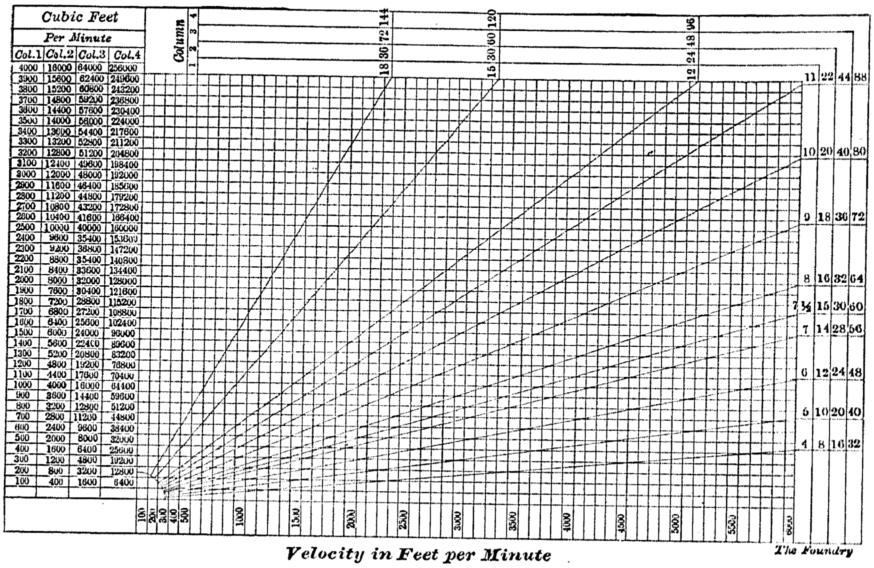
This table is used for figuring the lineal velocity of air through a pipe when the cubic feet per minute and diameter of pipe are known, or finding any of the factors when the other two are known.

$$\text{The table solves the formula, velocity in feet per minute} = \frac{\text{Cu. ft. per minute}}{\text{Area pipe in sq. ft.}}$$

Blower pipes are usually proportioned for a velocity of 3000 feet per minute.

For handling material by air in pipe, the velocity should be between 4000 and 6000 feet per minute, according to the size of the pipe and the density of the material.

Pipe Diameter in Inches



Cubic Feet Per Minute			
Col. 1	Col. 2	Col. 3	Col. 4
4000	16000	64000	256000
3900	15600	62400	249600
3800	15200	60800	243200
3700	14800	59200	236800
3600	14400	57600	230400
3500	14000	56000	224000
3400	13600	54400	217600
3300	13200	52800	211200
3200	12800	51200	204800
3100	12400	49600	198400
3000	12000	48000	192000
2900	11600	46400	185600
2800	11200	44800	179200
2700	10800	43200	172800
2600	10400	41600	166400
2500	10000	40000	160000
2400	9600	38400	153600
2300	9200	36800	147200
2200	8800	35200	140800
2100	8400	33600	134400
2000	8000	32000	128000
1900	7600	30400	121600
1800	7200	28800	115200
1700	6800	27200	108800
1600	6400	25600	102400
1500	6000	24000	96000
1400	5600	22400	89600
1300	5200	20800	83200
1200	4800	19200	76800
1100	4400	17600	70400
1000	4000	16000	64400
900	3600	14400	59600
800	3200	12800	51200
700	2800	11200	44800
600	2400	9600	38400
500	2000	8000	32000
400	1600	6400	25600
300	1200	4800	19200
200	800	3200	12800
100	400	1600	6400

Velocity in Feet per Minute

DIAMETER OF CUPOLA BLAST PIPES

TABLE OF DIAMETERS OF CUPOLA BLAST PIPES FOR LENGTHS 20 TO 140 FEET, AND LOSSES OF ¼ AND ½ OUNCE PRESSURE PER SQUARE INCH.

The friction varies as the square of the velocity and inversely as the diameter of the pipe, therefore, if the diameter of the pipe is doubled the friction loss is divided by 32 provided, of course, the same volume is carried.

The advisability of using a large pipe for conveying the air is shown by the following table which gives the size of pipe which should be used for pressure losses not exceeding one-fourth and one-half ounce per square inch, for various lengths of pipe.

Diameter of Blast Pipes

DIAMETERS OF BLAST PIPES

Tons of Iron per Hour	Inside Dia. of Cupola Inches	Cubic Ft of Air per Minute	Length of Pipe in Feet — Diameter of Pipe with Drop of: 20		40		60		80		100		120		140	
			¼ oz.	½ oz.	¼ oz.	½ oz.	¼ oz.	½ oz.	¼ oz.	½ oz.	¼ oz.	½ oz.	¼ oz.	½ oz.	¼ oz.	½ oz.
1	23	500	6	5	7	6	7	6	8	7	9	8	9	8	9	8
2	27	1,000	8	7	9	8	10	9	11	9	11	10	12	11	12	11
3	30	1,500	10	8	11	10	11	10	12	11	13	11	13	12	14	12
4	32	2,000	11	9	12	11	13	12	14	12	15	13	15	14	16	14
5	36	2,500	12	10	14	12	15	13	15	14	16	14	17	15	17	15
6	39	3,000	13	11	15	13	16	14	17	15	18	15	18	16	18	16
7	42	3,500	13	12	15	13	17	15	17	15	18	16	19	17	20	18
8	45	4,000	15	12	16	15	18	15	18	16	19	17	20	18	21	18
9	48	4,500	15	13	17	15	18	16	19	17	20	18	21	19	22	19
10	54	5,000	15	13	18	15	19	17	20	18	21	18	22	19	23	20
11	54	5,500	16	14	18	16	20	17	21	18	22	19	23	20	23	20
12	60	6,000	17	14	19	17	20	17	21	19	22	20	23	21	24	21
13	60	6,500	17	14	19	17	21	18	23	19	23	20	24	21	25	22
14	60	7,000	18	15	20	18	22	19	23	20	24	21	25	22	26	23
15	66	7,500	18	16	21	18	22	19	24	21	25	22	26	22	27	23
16	66	8,000	18	16	22	18	23	20	24	22	26	22	26	23	27	24
17	66	8,500	18	16	22	18	23	20	24	22	26	22	27	24	28	24
18	72	9,000	18	17	22	18	24	21	25	22	27	23	27	24	28	25
19	72	9,500	20	17	23	20	24	22	26	23	28	23	28	25	29	26
20	72	10,000	20	18	23	20	25	22	27	23	28	24	29	25	30	26
21	78	10,500	21	18	24	21	26	23	27	23	29	25	30	26	30	26
22	78	11,000	21	18	24	21	27	23	28	24	29	26	30	27	31	27
23	78	11,500	21	19	25	21	27	24	28	25	30	26	30	27	31	27
24	84	12,000	22	19	25	22	28	24	28	25	31	26	31	27	32	28
25	84	12,500	22	19	26	22	28	24	29	26	31	27	32	28	33	28
26	84	13,000	22	19	26	22	28	24	29	26	31	27	32	28	33	28
27	90	13,500	23	20	26	23	28	24	30	26	31	27	32	28	34	28
28	90	14,000	23	20	27	23	29	25	30	27	32	28	33	29	34	29
29	90	14,500	23	20	27	23	29	26	31	27	32	28	33	29	34	30
30	90	15,000	24	21	27	24	29	26	31	27	32	28	34	30	35	30

The minimum radius of each turn should be equal to the diameter of the pipe. For each turn thus made add three feet in length, when using this table. If the turns are of less radius, the length added should be increased proportionately.

The minimum radius of each turn should be equal to the diameter of the pipe. For each turn thus made add three feet in length, when using this table. If the turns are of less radius, the length added should be increased proportionately.

DIAMETER OF CUPOLA BLAST PIPES
(*Concluded*)

DIAMETERS OF PIPE FOR LENGTHS FROM 30 TO 300 FEET, BLOWER OUTLETS VARYING FROM 3 TO 24 INCHES

Length of pipe, feet	30	60	90	120	150	180	210	240	270	300
Diameter of blower outlet, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches	Diameter of pipe, inches
3	3¼	3⅝	4	4¼	4½	4¾	5	5⅛	5⅜	5½
3½	3¾	4⅛	4½	4⅞	5	5¼	5½	5⅝	5⅝	6⅛
4	4⅜	4¾	5⅛	5⅜	5¾	6	6¼	6½	6¾	7
4½	5	5⅜	5¾	6	6⅜	6⅜	7	7¼	7½	7⅞
5	5½	6	6⅜	6¾	7⅛	7½	7¾	8⅛	8⅜	8¾
6	6½	7	7⅝	8	8½	9	9⅜	9¾	10⅛	10½
7	7⅝	8¼	8⅞	9⅜	10	10⅜	10⅞	11⅞	11¾	12⅛
8	8¾	9½	10⅛	10¾	11⅜	11⅞	12⅜	12⅜	13⅜	13⅞
9	10	10¾	11½	12⅛	12¾	13⅜	14	14½	15⅛	15⅝
10	11	11⅞	12¾	13½	14¼	14⅞	15½	16⅛	16¾	17⅜
11	12	13	13⅞	14¾	15⅝	16⅜	17⅛	17¾	18½	19⅛
12	13⅛	14¼	15¼	16⅛	17	17⅞	18⅝	19⅜	20⅛	20⅞
13	14¼	15⅜	16½	17½	18⅜	19¼	20⅛	21	21¾	22⅝
14	15⅜	16⅝	17¾	18⅞	19¾	20¾	21¾	22⅝	23½	24¼
15	16½	17¾	19	20⅛	21¼	22¼	23¼	24¼	25⅛	26
16	17½	19	20⅜	21½	22⅝	23¾	24¾	25⅞	26⅞	27¾
17	17⅝	20⅛	21½	22¾	24	25¼	26⅜	27½	28½	29½
18	19¾	21⅜	22¾	24¼	25½	26¾	27⅞	29⅛	30⅛	31¼
19	20⅞	22½	24	25½	27	28¼	29½	30¾	31⅞	33
20	22	23⅝	25⅜	27⅞	28⅜	29¾	31	32¼	33½	34¾
21	23	24⅞	26⅝	28¼	29¾	31⅛	32½	33⅞	35¼	36⅜
22	24⅛	26⅛	27⅞	29½	31⅛	32⅝	34⅛	35½	36⅞	38⅛
23	25¼	27¼	29⅛	30⅞	32½	34⅛	35⅝	37⅛	38½	39⅞
24	26½	28½	30⅜	32¼	34	35⅝	37¼	38¾	40¼	41⅝
Length of Mouthpiece, inches	9	15	21	27	33	39	42	48	54	60

CAPACITY TABLE OF STEEL PRESSURE BLOWERS FOR CUPOLA SERVICE

Cupola		Tuyeres		Iron	Air			Blower				Pipe	
Diameter of nside lining, inches	Area of inside lining, square inches	Number of tuyeres	Total tuyeres area, square inches	Melting capacity, pounds per hour	Cubic feet air per minute required	Pressure, ounces per square inch	Speed of blower, revolutions per minute	Pressure produced, ounces per square inch	Capacity of blower, cubic feet air per minute	Brake horsepower required to drive blower	Diameter of outlet, inches	Diameter of pipe, inches	Air velocity in pipe
18	254	2	51	1,775	444	7.5	.....	..	......	......	....	..	......
23	415	4	83	3,090	773	8.5	4,150	9	752	4.20	5¾	9	1,800
27	573	8	115	4,420	1,105	9.2	3,740	10	1,093	6.78	6¾	10	1,900
32	804	8	161	6,480	1,620	10.00	2,880	10	1,840	11.40	8¾	13	1,900
37	1,075	8	215	8,980	2,245	10.76	2,595	10	2,280	14.13	9¾	15	1,900
42	1,385	12	277	11,960	2,990	11.46	2,470	11	2,910	19.85	10¾	16	2,000
45	1,590	12	318	13,960	3,490	11.88	2,080	11	3,930	26.80	12½	19	2,000
48	1,810	12	362	16,120	4,040	12.25	2,170	12	4,110	30.60	12½	19	2,100
54	2,290	12	458	21,050	5,260	13.00	1,995	13	5,360	43.25	14	21	2,200
60	2,827	12	566	26.630	6,650	13.70	1,728	13	7,010	56.66	16	24	2,200
66	3,421	12	685	33,000	8,250	14.33	1,540	13	8,390	67.66	17½	26	2,200
72	4,071	12	814	40,150	10,020	15.00	1,393	13	10,140	82.00	19¼	29	2,200
78	4,778	12	955	48,000	12,000	15.66	1,318	14	12,520	109.00	21	32	2,300
84	5,542	12	1,109	56,750	14,200	16.20	1,410	16	13,380	132.75	21	33	2,400
87	5,945	16	1,189	61,600	15,400	16.50	1,340	16	15,675	155.66	22¾	35	2,400

Note—After installing one of these blowers, if the air pressure should be less than is given above, it indicates that too much air is flowing and results in more power being required to drive the blower than is specified. A blast gate should be inserted in the pipe between blower and cupola, and closed sufficiently to reduce the power to that given in the table; then the volume will be correct for the highest melting efficiency obtainable with the cupola, regardless of proportions or resistance, as the table is based on the greatest resistance usually encountered.

AIR HANDLED BY DUST-COLLECTING HOODS

Cubic Feet of Air at 65 Degrees Fahr. Handled per Minute Through Average Dust-Collecting Hoods

(Based on Coefficient of Orifice of 0.71 with 10 Per Cent Added for Leakage.)

Diameter of connection pipe, inches	Maintained Suction—Inches Water Gauge						
	1	1½	2	2½	3	4	5
1½	38	47	54	61	67	76	86
2	68	84	97	108	118	136	153
2½	107	131	161	168	185	214	238
3	153	188	217	243	266	306	343
3½	209	256	296	330	362	418	466
4	273	334	386	431	473	546	609
4½	345	423	488	546	598	690	775
5	427	523	605	676	741	854	955
6	614	751	867	970	1,062	1,228	1,373
7	835	1,023	1,181	1,322	1,448	1,670	1,870
8	1,092	1,337	1,546	1,727	1,892	2,184	2,440
9	1,381	1,694	1,953	2,184	2,387	2,762	3,091
10	1,705	2,090	2,409	2,695	2,959	3,410	3,806

Connection Pipes for Grinding and Polishing Wheels

The sizes of connections suggested for grinding and polishing wheels are those given in the tables by the department of labor of New York, with the exceptions of those for polishing wheels 21 inches and over in diameter.

MINIMUM SIZES OF BRANCH PIPES FOR EMERY OR OTHER GRINDING WHEELS

Diameter of wheels	Maximum grinding surface square inches	Minimum diameter of branch pipe in inches
6 inches or less, not over 1 inch thick	19	3
7 inches to 9 inches, inclusive, not over 1½ inches thick	43	3½
10 inches to 16 inches, inclusive, not over 2 inches thick	101	4
17 inches to 19 inches, inclusive, not over 3 inches thick	180	4½
20 inches to 24 inches, inclusive, not over 4 inches thick	302	5
25 inches to 30 inches, inclusive, not over 5 inches thick	472	6

MINIMUM BRANCH PIPES FOR BUFFING, POLISHING OR RAG WHEELS

Diameter of wheels	Maximum grinding surface square inches	Minimum diameter of branch pipe in inches
6 inches or less, not over 1 inch thick	19	3½
7 inches to 12 inches, inclusive, not over 1½ inches thick	57	4
13 inches to 16 inches, inclusive, not over 2 inches thick	101	4½
17 inches to 20 inches, inclusive, not over 3 inches thick	189	5
21 inches to 27 inches, inclusive, not over 4 inches thick	338	6
27 inches to 33 inches, inclusive, not over 5 inches thick	518	7

Where the branches are extremely long, the friction loss in the system may be decreased by making pipes ½ inch greater in diameter than the sizes given in above tables.

GRINDING WHEEL STANDARDS

REVOLUTIONS PER MINUTE FOR VARIOUS SIZES OF GRINDING WHEELS TO GIVE PERIPHERAL SPEED IN FEET PER MINUTE AS INDICATED

FROM SAFETY CODE APPROVED BY ABRASIVE WHEEL MANUFACTURERS

Diameter of Wheel in Inches	4,000	4,500	5,000	5,500	6,000	6,500
1	15,279	17,200	19,099	21,000	22,918	24,850
2	7,639	8,590	9,549	10,500	11,459	12,420
3	5,093	5,725	6,366	7,000	7,639	8,270
4	3,820	4,295	4,775	5,250	5,730	6,205
5	3,056	3,440	3,820	4,200	4,584	4,970
6	2,546	2,865	3,183	3,500	3,820	4,140
7	2,183	2,455	2,728	3,000	3,274	3,550
8	1,910	2,150	2,387	2,635	2,865	3,100
10	1,528	1,720	1,910	2,100	2,292	2,485
12	1,273	1,453	1,592	1,750	1,910	2,070
14	1,091	1,228	1,364	1,500	1,637	1,773
16	955	1,075	1,194	1,314	1,432	1,552
18	849	957	1,061	1,167	1,273	1,380
20	764	860	955	1,050	1,146	1,241
22	694	782	868	952	1,042	1,128
24	637	716	796	876	955	1,035
26	586	661	733	809	879	955
28	546	614	683	749	819	887
30	509	573	637	700	764	827
32	477	537	596	657	716	776
34	449	506	561	618	674	730
36	424	477	531	534	637	689
38	402	453	503	553	603	653
40	382	430	478	525	573	621
42	364	409	455	500	546	591
44	347	391	434	477	521	564
46	332	374	415	456	498	539
48	318	358	397	438	477	517
50	306	344	383	420	459	497
52	294	331	369	404	441	487
54	283	318	354	389	425	459
56	273	307	341	366	410	443
58	264	296	330	354	396	428
60	255	277	319	350	383	414

GRINDING WHEEL STANDARDS
(Concluded)

OF TAPERED FLANGES AND TAPERED WHEELS WHERE HOODS ARE NOT USED

FROM SAFETY CODE APPROVED BY ABRASIVE WHEEL MANUFACTURERS

el	A	B	C	D	E	F
	0	1	3	3/8	2	3/8
	0	1	5	3/8	3 1/2	3/8
	0	2	6	1/2	4	1/2
	4	4 1/2	6	5/8	4	5/8
	4	4 1/2	8	5/8	5 1/2	3/4
	4	6	10	5/8	7	7/8
	4	6	12	3/4	8	1
	4	6	14	3/4	9	1
	4	6	16	3/4	10 1/2	1 1/8
	4	6	18	3/4	12	1 1/8
	4	6	20	3/4	13 1/2	1 1/8
	4	6	22	7/8	14 1/2	1 1/4
	4	6	24	7/8	16	1 1/4

flat spot at center of flange.
t center of wheel.
diameter of flange.
D—Minimum thickness of flange at bore.
E—Minimum diameter of recess in taper flanges
F—Minimum thickness of each flange for single taper at bore.

SIZES OF MACHINE SPINDLES IN INCHES FOR VARIOUS DIAMETERS AND THICKNESSES OF GRINDING WHEELS

FROM SAFETY CODE APPROVED BY ABRASIVE WHEEL MANUFACTURERS

THICKNESS OF WHEEL IN INCHES

1/2	5/8	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	4	4 1/2	5
1/2	1/2	1/2	1/2	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1
1/2	1/2	5/8	5/8	5/8	3/4	3/4	3/4	3/4	3/4	3/4	1	1	1	1	1	1
5/8	5/8	5/8	5/8	3/4	3/4	3/4	1	1	1	1	1	1	1	1 1/4	1 1/4	1 1/4
5/8	5/8	3/4	3/4	3/4	3/4	1	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4
3/4	3/4	3/4	3/4	3/4	3/4	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2
3/4	3/4	3/4	1	1	1	1	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2
7/8	7/8	1	1	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2
		1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 3/4
		1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 7/8	1 7/8
			1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 7/8	1 7/8	1 7/8	1 7/8
			1 1/2	1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 3/4	1 3/4	1 3/4	2	2	2	2	2
				1 1/2	1 1/2	1 3/4	1 3/4	1 3/4	1 3/4	2	2	2	2	2 1/4	2 1/4	2 1/4
					1 3/4	1 3/4	2	2	2	2	2	2 1/4	2 1/4	2 1/2	2 1/2	2 1/2
						2	2 1/4	2 1/4	2 1/4	2 1/2	2 1/2	2 1/2	2 3/4	2 3/4	3	3

CAUSES OF GRINDING WHEEL ACCIDENTS

Broken wheels (caused by)	Cracked wheel (caused by)	Improper inspection of wheel	Before issued to operator.		
			When being mounted.		
		Dropping or striking against some object while not being operated.	During storage		Carelessness. Horseplay.
			While being mounted		
			While standing		
		Being forced on improper sized spindle	Too small bushing.		
			Too large spindle.		
		Heated Spindle	Tight bearings		Lack of oil. Improper spindle size.
			Inner flange not fixed on spindle.		
		Only one flange	Careless mounting.		
			Ignorance.		
		Uneven bearing of flanges	Bent or broken flange or flanges		Improper specifications. Ignorance.
			Bushings projecting beyond sides of wheels		
			High spots on flanges		
			High spots on wheels		
		Flanges of different diameters	Careless mounting.		
			Ignorance.		
		Flanges not properly relieved	Entirely without relief		Improper specifications. Ignorance.
			Diameter of relief too small		
		Compressible washers	Missing		Carelessness. Ignorance
			Too thin		
			Too small diameter		
		Tightening of nut	Carelessness.		
			Ignorance of mounter.		
		Hacking of wheel	Desire for increased cutting.		
			No restriction on use of wheel.		
		Screwing-wheel on taper arbor	Ignorance.		
	Too-high rim speed (caused by)	Spindle overspeeded	Overspeed when first set up.		
			Speed increased		Desire for increased cutting. Thoughtlessly increasing speed of line shaft.
			Use of cone pulley.	Shifting to small pulley	Desire for increased cutting. Loose shifter. Carelessness.
		Use of too large wheel for spindle speed	Wheel initially too large		Carelessness. Ignorance.
			Too large wheel substituted		Desire for increased cutting. Ignorance or indifference.
			Wheel of different grain and lower recommended speed substituted.		Ignorance or indifference.
			Wheel of different shape substituted		

CAUSES OF GRINDING WHEEL ACCIDENTS
(*Concluded*)

Broken wheels (caused by)	Catching work between rest and wheel (caused by)	Improper adjustment of rest	Lack of attention. Ignorance.
		Improper handling of work	Side grinding when rest not designed for it. Pushing work under rest . . . . Ignorance.
	Out of true (caused by)	Loose bearings	Lack of attention. Ignorance.
		Bent spindle	Lack of attention. Ignorance.
		Loose frame	Lack of attention Ignorance.
		Rough or improper use	Inexperienced men. Responsibility of foreman.
	Unbalanced wheel (caused by)	Wheel standing in water (see under "cracked wheel"). Side grinding (see below). Wheel untrue.	
	Weakened wheel (caused by)	Wheel standing in water (see above). Side grinding (see below). Hacking wheel (see above).	
	Too small spindle (caused by)	Bushing too small in wheel Wrong spindle used for size of wheel	Ignorance or indifference.
	Side grinding on improper wheel (caused by)	Lack of proper equipment. Inexperience of men. Indifference.	
Flying wheel unbroken (caused by)	Mounted so that nut works loose (caused by)	Spindle threaded in wrong direction	Improper specifications.
		Belt twisted so that machine runs opposite to initial direction	Equipment incorrectly erected.
		Motor reversed Spindle turned end for end	Ignorance.
Work or dresser hurled out of workman's hand (caused by)	Caught between rest and wheel.	See above	
Flying particles of emery inhaled or in eye (caused by)	Exhauster defective (caused by)	Entire lack of exhauster	Exhauster not provided. Exhauster disconnected.
		Exhauster line not proper size	Ignorance. Desire for saving expense.
		Exhauster line stopped up	Not often cleaned. Poorly designed or constructed
	Eye protection insufficient (caused by)	No goggles provided. Improper goggles provided.	
		Goggles not used	Prejudice. Carelessness. Fear of infection.
	Chip guard defective (caused by)	No chip guard.	
		Chip guard not in use	Broken and not replaced. Prejudice of workmen.
Flying pieces of broken revolving type of dresser caused by)	No guard for dresser.		

CAUSES OF GRINDING WHEEL ACCIDENTS

Broken wheels (caused by)	Cracked wheel (caused by)	Improper inspection of wheel	Before issued to operator.		
			When being mounted.		
		Dropping or striking against some object while not being operated.	During storage	Carelessness. Horseplay.	
			While being mounted		
			While standing		
		Being forced on improper sized spindle	Too small bushing.		
			Too large spindle.		
		Heated Spindle	Tight bearings	Lack of oil. Improper spindle size.	
			Inner flange not fixed on spindle.		
		Only one flange	Careless mounting.		
			Ignorance.		
		Uneven bearing of flanges	Bent or broken flange or flanges	Improper specifications. Ignorance.	
			Bushings projecting beyond sides of wheels		
			High spots on flanges		
			High spots on wheels		
		Flanges of different diameters	Careless mounting.		
			Ignorance.		
		Flanges not properly relieved	Entirely without relief	Improper specifications. Ignorance.	
			Diameter of relief too small		
		Compressible washers	Missing	Carelessness. Ignorance	
			Too thin		
			Too small diameter		
		Tightening of nut	Carelessness.		
			Ignorance of mounter.		
		Hacking of wheel	Desire for increased cutting.		
			No restriction on use of wheel.		
		Screwing-wheel on taper arbor	Ignorance.		
	Too-high rim speed (caused by)	Spindle overspeeded	Overspeed when first set up.		
			Speed increased	Desire for increased cutting. Thoughtlessly increasing speed of line shaft.	
			Use of cone pulley	Shifting to small pulley	Desire for increased cutting. Loose shifter. Carelessness.
			Wheel initially too large	Carelessness. Ignorance.	
			Too large wheel substituted	Desire for increased cutting. Ignorance or indifference.	
		Use of too large wheel for spindle speed	Wheel of different grain and lower recommended speed substituted.	Ignorance or indifference.	
			Wheel of different shape substituted		

CAUSES OF GRINDING WHEEL ACCIDENTS
(*Concluded*)

Broken wheels (caused by)	Catching work between rest and wheel (caused by)	Improper adjustment of rest	Lack of attention. Ignorance.
		Improper handling of work	Side grinding when rest not designed for it. Pushing work under rest............Ignorance.
	Out of true (caused by)	Loose bearings	Lack of attention. Ignorance.
		Bent spindle	Lack of attention. Ignorance.
		Loose frame	Lack of attention Ignorance.
		Rough or improper use	Inexperienced men. Responsibility of foreman.
	Unbalanced wheel (caused by)	Wheel standing in water (see under "cracked wheel"). Side grinding (see below). Wheel untrue.	
	Weakened wheel (caused by)	Wheel standing in water (see above). Side grinding (see below). Hacking wheel (see above).	
	Too small spindle (caused by)	Bushing too small in wheel Wrong spindle used for size of wheel	Ignorance or indifference.
	Side grinding on improper wheel (caused by)	Lack of proper equipment. Inexperience of men. Indifference.	
Flying wheel unbroken (caused by)	Mounted so that nut works loose (caused by)	Spindle threaded in wrong direction	Improper specifications.
		Belt twisted so that machine runs opposite to initial direction	Equipment incorrectly erected.
		Motor reversed Spindle turned end for end	Ignorance.
Work or dresser hurled out of workman's hand (caused by)	Caught between rest and wheel.	See above.	
Flying particles of emery inhaled or in eye (caused by)	Exhauster defective (caused by)	Entire lack of exhauster	Exhauster not provided. Exhauster disconnected.
		Exhauster line not proper size	Ignorance. Desire for saving expense.
		Exhauster line stopped up	Not often cleaned. Poorly designed or constructed
	Eye protection insufficient (caused by)	No goggles provided. Improper goggles provided.	
		Goggles not used	Prejudice. Carelessness. Fear of infection.
	Chip guard defective (caused by)	No chip guard.	
		Chip guard not in use	Broken and not replaced. Prejudice of workmen.
Flying pieces of broken revolving type of dresser caused by)	No guard for dresser.		

CUPOLA PRACTICE

Half of the coke bed should be charged first and the remaining coke the bed should not be charged until a strong blue flame is produced, a metal should not be charged until the blue flame appears through the c last charged. The cupola should be allowed to heat up before putting the blast. Metal should begin to flow in from 8 to 10 minutes after blast is on. If a longer time is required, too much coke has been used the bed. Usually, the bed should be 28 to 36 inches above the tuyeres, pending on the style of the tuyeres and the diameter of the cupola. slag hole should be at least 6 inches below the bottom of the tuyeres prevent slag clogging them.

The patched zone of the cupola should be less than 1 foot wide. wider section indicates irregular height of the bed at different stages of heat.

At least 25 pounds of limestone per ton of metal should be added each charge except the last. More should be added if the slag is not fl

The metal charge should be 1½ pounds per square inch of the horizo cross section of the melting zone.

A ratio of 8 of metal to 1 of coke on a charge is most frequently but some foundrymen melt with a ratio as high as 11 to 1, and others as low as 6 to 1.

A cupola should melt 10 pounds per hour for every square incl cross-sectional area inside the lining. The area is determined by multipl the square of the radius by π. Thus the radius of a cupola lined t inches is 30; the square of this is 30 x 30 which equals 900; this multi by π (3.1416) equals 2827. The cross-sectional area of 2827 square i multiplied by 10 equals 28,270 which is the number of pounds of metal v should be melted per hour in a 60-inch cupola.

It is estimated that 30,000 cubic feet of air are required for each of iron melted. Thus for a 60-inch cupola which melts 14 ton of meta hour 420,000 cubic feet of air are required per hour.

The tuyere area should be approximately one-ninth of the cross-sec area of the melting zone.

MELTING POINTS OF THE CHEMICAL ELEMENTS

Element	Cent.	Fahr.	Element	Cent.	Fahr.	Element.	Cent.	Fahr.
Helium	*—271	—456	CADMIUM	320.9	609.6	Cobalt	1,480	2,696
Hydrogen	—259	—434	LEAD	327.4	621.3	Yttrium	1,490	2,714
Neon	—253?	—423	ZINC	419.4	786.9	Chromium	1,520	2,768
Fluorine	—223	—369	Tellurium	452	846	IRON	1,530	2,786
Oxygen	—218	—360	ANTIMONY	630.0	1,166	PALLADIUM	1,549	2,820
Nitrogen	—210	—346	Cerium	640	1,184	Zirconium	1,700?	3,090
Argon	—188	—306	Magnesium	651	1,204	Columbium		
Krypton	—169	—272	ALUMINUM	658.7	1,217.7	(Niobium)	1,700?	3,090
Xenon	—140	—220	Radium	700	1,292			
Chlorine	—101.5	—150.7	Calcium	810	1,490	Thorium	**1,700	3,090
MERCURY	— 38.9	— 38.0	Lanthanum	810?	1,490		*Pt.	Pt
Bromine	— 7.3	+ 18.9	Strontium	**Ca*Ba?	.....	Vanadiun	1,720	3,128
Caesium	+ 26	79	Neodymium	840?	1,544	PLATINUM	1,755	3,191
Gallium	30	86	Arsenic	850?	1,562	Ytterbium	?	.....
Rubidium	38	100	Barium	850	1,562	Titanium	1,800	3,272
Phosphorus	44	111.2	Praseodymium	940?	1,724	Uranium	*1,850	3,362
Potassium	62.3	144	Germanium	958	1,756	Rhodium	1,950	3,542
Sodium	97.5	207.5	SILVER	960.5	1,761			
Iodine	113.5	236.3	GOLD	1,063.0	1,945.5	Boron	2,200–2,500?	4,000-4,500
Sulphur	S1 112.8	235.0	COPPER	1,083.0	1,981.5	Iridium	2,350?	4,262
	S11 119.2	246.6	Manganese	1,260	2,300	Ruthenium	2,450?	4,442
	S111 106.8	224.2	Samarium	1,300–1,400	2,370—2,550	Molybdenum	2,500?	4,500
Indium	155	311						
Lithium	186	367	Beryllium			Osmium	2,700?	4,900
Selenium	217—220	422—428	(Glucinum)	1,350?	2,462	Tantalum	2,850	5,160
TIN	231.9	449.4	Scandium	?	.....	TUNGSTEN	3,000	5,430
Bismuth	271	520	Silicon	1,420	2,588	Carbon	**3,600 for p=1At.	6,500 for p=1At
Thallium	302	576	NICKEL	1,452	2,646			

* Less than
** More than

SHRINKAGE OF CASTINGS PER FOOT

Metals—	Fractions of an inch.	Decimals of an inch.
Pure aluminum	13/64	0.2031
Nickel aluminum casting alloy	3/16	0.1875
"Special Casting Alloy," made by the Pittsburg Reduction Co.	11/64	0.1718
Iron, small cylinders	1/16	0.0625
Iron, pipes	1/8	0.1250
Iron, girders, beams, etc.	1/64	0.1000
Iron, large cylinders contraction of diameter at top	5/8	0.6250
Iron, large cylinders, contraction of diameter at bottom	5/64	0.0830
Iron, large cylinders, contraction in length	3/32	0.0940
Cast iron	1/8	0.1250
Steel	1/4	0.2500
Malleable iron	1/8	0.1250
Tin	1/12	0.0833
Britannia	1/32	0.0312
Thin brass castings	11/64	0.1670
Thick brass castings	5/32	0.1500
Zinc	5/16	0.3125
Lead	5/16	0.3125
Copper	3/16	0.1875
Bismuth	5/32	0.1563

TUMBLING BARREL EXHAUSTS

Sizes of Exhaust Pipes for Tumbling Barrels

Diameter of mill, inches	Length of Barrel, Inches: 36 — Diameter of pipe, inches	48 — Diameter of pipe, inches	60 — Diameter of pipe, inches	72 — Diameter of pipe, inches	84 — Diameter of pipe, inches
24	4	4	5	6	6
30	4	4	5	6	6
36	5	5	6	6	7
42	6	6	6	7	8
48	6	6	7	8	8

Diameter of Exhaust Fan Inlets for Tumbling Barrels

Diameter of pipe to mill inches	Number of Mills: 1 — Inlet diameter, inches	2 — Inlet diameter, inches	3 — Inlet diameter, inches	4 — Inlet diameter, inches	5 — Inlet diameter, inches	6 — Inlet diameter, inches	7 — Inlet diameter, inches	8 — Inlet diameter, inches	9 — Inlet diameter, inches	10 — Inlet diameter, inches
4	4¾	6½	6½	8½	8½	10½	10½	12	12	12
5	5½	6½	8½	10½	12	12	14	14	16	16
6	6½	8½	10½	12	14	14	16	18	18	20
7	6½	10½	12	14	16	18	18	20	22	24
8	8½	12	14	16	18	20	22	24	24	27

SIZES OF PIPES FOR FORGES AND FURNACES

	Number of Forges									
	1	2	3	4	5	6	7	8	9	10
Tuyere Diameter, Inches	Diameter of Pipe, Inches									
¾	1½	1½	2	2	2½	2½	3	3	3	3
1	1½	2	2½	3	3	3½	3½	4	4	4
1¼	2	2½	3	3½	4	4	4½	5	5	5
1½	2	3	3½	4	4½	5	6	6	6	6
1¾	2½	3½	4	4½	5	6	6	7	7	7
2	3	4	4½	5	6	7	7	8	8	8
2½	3	4	5	6	7	7	8	9	9	9
2½	3½	5	6	7	8	8	9	9	10	10
2¾	4	5	6	7	8	9	10	10	11	11
3	4	6	7	8	9	10	11	11	12	12
3½	4½	7	8	9	10	11	12	13	14	14
4	6	8	9	11	12	13	14	15	16	17

Explanation.—Wanted a suitable blower for five forges having 2-inch tuyeres.

Refer to table above, under "Tuyere Diameter," find 2-inch; go to right and under column headed 5 to find 6 inches, which is the proper diameter of discharge from blower. In ordering blower it is well to outline the duty fully and have manufacturers recommend speeds and pressures to carry. For example, a volume type of blower is usually recommended for coal or coke furnaces having 3 to 4-inch tuyeres, and pressures as low as 3 to 4 ounces are carried—whereas for oil furnaces the pressure type is used, producing pressures of 8 ounces or more.

TONNAGE OF PIG IRON IN PILES OR RICKS

Width of Pile in Inches	Net Tons in Piles One Foot High — Length of Pile in Feet: 5	10	15	20	25	30	35	40	45	50	75	100
12	0.69	1.38	2.07	2.76	3.45	4.14	4.83	5.52	6.21	6.90	10.35	13.80
20	1.15	2.30	3.45	4.60	5.75	6.90	8.05	9.20	10.35	11.50	17.25	23.00
24	1.38	2.76	4.14	5.52	6.90	8.28	9.66	11.04	12.40	13.80	20.70	27.60
36	2.07	4.14	6.21	8.28	10.35	12.42	14.50	16.56	18.63	20.70	31.05	41.40
40	2.30	4.60	6.90	9.20	11.50	13.80	16.10	18.40	20.70	23.00	34.50	46.00
48	2.76	5.52	8.28	11.04	13.80	16.56	19.32	22.10	24.85	27.60	41.40	55.20
60	3.45	6.90	10.35	13.80	17.25	20.70	24.15	27.60	31.05	34.50	51.75	69.00

To find tonnage in a given pile.—Multiply the value found in the table by the height of the pile in feet.

Example.—Find tonnage in a pile 40 feet long, 24 inches wide and 6 feet high.

In the column under 40 feet, on the line marked 24 inches we find 11.04.

$11.04 \times 6 = 66.24$ tons.

The values in the table are computed on a basis of $7\frac{1}{4}$ cubic feet per ton, the pigs being piled in the usual ricks. If very closely piled, the iron will occupy as low as 7 cubic feet per ton. Pig iron in a loose heap will run about 8 cubic feet to the ton.

Sand-cast pigs usually are 40 inches long and 4 inches in cross-section, but before shipment from the furnace the pigs and sows are broken into pieces about 20 inches long. Machine-cast pigs may be 10, 12 or 15 inches long.

To reduce values in the table to gross tons, 2,240 pounds, multiply by 0.89 or divide by 1.12.

TONNAGE OF COKE IN BINS

NET TONS IN BINS ONE FOOT DEEP

Width in Feet	Length in Feet 10	12	15	18	20	25	30	40	50	75	100
10	1.67	.....	.....	.....	.....	.....	.....	.....	.....	12.50	16.70
12	2.00	2.40	.....	.....	.....	.....	.....	.....	.....	15.00	20.00
15	2.50	3.00	3.75	.....	.....	.....	.....	.....	.....	18.75	25.00
18	3.00	3.60	4.50	5.40	.....	.....	.....	.....	.....	22.50	30.00
20	3.35	4.00	5.00	6.00	6.70	.....	.....	.....	.....	25.00	33.50
25	4.17	5.00	6.25	7.50	8.35	10.40	.....	.....	.....	31.30	47.70
30	5.00	6.00	7.50	9.00	10.00	12.50	15.00	.....	.....	37.50	50.00
40	6.67	8.00	10.00	12.00	13.43	16.67	20.00	26.70	.....	50.00	66.70
50	8.34	10.00	12.50	15.00	16.67	20.80	25.00	33.33	41.70	62.50	83.40

To find tonnage in a given bin.—Multiply the value found in the table by the average depth of coke in the bin.

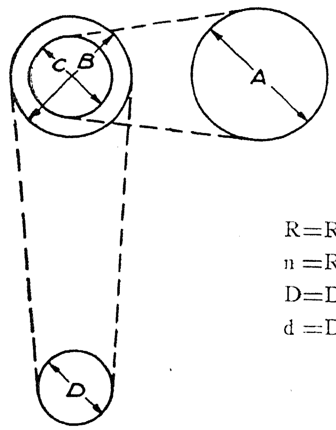
Example.—In a bin 18 x 25 feet in size, with coke 5 feet deep, we find in the column headed 18 feet, on the line opposite 25 feet, the value 7.50.

$7.50 \times 5 = 37.5$ tons.

A good grade of foundry coke will run from 32 to 34 pounds per cubic foot. The values in the table are computed on a basis of 60 cubic feet per ton.

Pea coke averages 37 to 38 pounds per cubic foot, or about 53.4 cubic feet per ton. To reduce values in the table to a pea coke basis, multiply by 1.12.

DATA ON BELTS AND PULLEYS



Revolutions Per Minute of Driven Pulleys

The number of revolutions per minute of a driven pulley is equal to the product of the revolutions per minute of the driving pulley and the diameter of the driving pulley divided by the diameter of the driven pulley. Or where

R=Revolutions per minute of the driven pulley.
n =Revolutions per minute of the driving pulley.
D=Diameter of the driven pulley.
d =Diameter of the driving pulley.

$$R=\frac{dn}{D}$$

Diameters of Driven Pulleys

The diameter of a driven pulley is equal to the product of the revolutions per minutes of the driving pulley and the diameter of driving pulley divided by the revolutions per minute of driven pulley.

$$D=\frac{dn}{R}$$

Diameters of Driving Pulleys

The diameters of a drivinlg pulley is equal to the product of the diameter of driven pulley and revolutions per minute of driven pulley divided by revolutions per minute of driving pulley.

$$d=\frac{DR}{n}$$

Revolutions Per Minute of Driving Pulley

The number of revolutions per minute of a driving pulley is equal to the product of the diameter of driven pulley and the revolutions per minute of driven pulley divided by the diameter of driving pulley.

$$n=\frac{DR}{d}$$

DATA ON BELTS AND PULLEYS
(Continued)

Revolutions Per Minute of Driven Pulley in Compound Drive

The number of revolutions per minute of the second driven pulley is equal to the product of the revolutions of the first driving pulley and the quotient obtained by dividing the product of diameters of driving pulleys by the product of diameters of driven pulleys. Or where,

A and B=Diameters of the driving pulleys.
C and D=Diameters of the driven pulleys.
N=Revolutions per minute of second driven pulley.
n =Revolutions per minute of first driving pulley.

$$N = \frac{nAB}{CD}$$

Pulley Diameters in Compound Drive

Place the revolutions per minute of the driving pulley as the numerator of a fraction and the revolutions per minute of the driven pulley as the denominator, and reduce this fraction to its lowest terms. Then resolve both numerator and denominator into two factors and multiply each pair of factors (that is one in the denominator and one in the numerator) by a number which will give pulleys of large enough diameter.

Example: The number of revolutions per minute of A=320 per minute.
The number of revolutions per minute of D=900 per minute.

$$\text{Fraction} = \frac{320}{900} = \frac{16}{45} \text{ resolve into factors } \frac{8 \times 2}{9 \times 5}$$

$$\text{Multiplying pairs by same numbers} = \frac{(8 \times 1) \times (2 \times 4)}{(9 \times 1) \times (5 \times 4)}$$

$$\text{or } \frac{8 \times 8}{9 \times 20}$$

∴ 8 and 8 are diameters of driven pulleys C and D and 9 and 20 are diameters of driving pulleys.

DATA ON BELTS AND PULLEYS
(*Continued*)

VELOCITIES OF BELTS OR PULLEYS

ALL PULLEY DIAMETERS GIVEN IN INCHES.

Dia. of Pulley	Velocity of Belt or Pulley in Feet Per Minute when Number of Revolutions Per Minute Is 100	110	120	130	140	150	160	170	180	190	200	250
2	52	58	63	68	73	79	84	94	94	99	105	131
2½	66	72	79	85	92	98	105	111	118	124	131	164
3	79	86	94	102	110	118	126	134	141	149	157	196
3½	92	101	110	119	128	137	147	156	165	174	183	229
4	105	115	126	136	146	157	167	178	188	199	209	261
4½	118	130	141	153	165	177	188	200	212	224	236	295
5	131	144	157	170	183	196	209	223	236	249	262	327
5½	144	158	173	187	202	216	230	245	259	274	288	360
6	157	173	189	204	220	236	251	267	283	299	314	393
6½	170	187	204	221	238	255	272	289	306	323	340	425
7	183	202	220	238	257	275	293	311	330	348	367	458
7½	196	216	236	255	275	295	314	334	353	373	393	491
8	209	230	251	272	293	314	335	356	377	398	419	524
8½	223	245	267	289	312	334	356	378	401	423	445	556
9	236	259	283	306	330	353	377	401	424	448	471	589
9½	249	274	298	323	348	373	398	423	448	473	497	622
10	262	288	314	340	367	393	419	445	471	497	524	655
10½	275	302	330	357	385	412	440	467	495	522	550	687
11	288	317	346	374	403	432	461	490	518	547	576	720
11½	301	331	361	391	422	452	482	512	542	572	602	753
12	314	345	377	408	440	471	503	534	565	598	628	785
12½	327	360	393	425	458	491	524	556	589	622	655	818
13	340	375	408	443	477	511	545	579	613	647	681	852
13½	353	389	424	459	495	530	565	601	636	671	707	883
14	367	403	440	477	513	550	586	623	660	696	733	916
14½	380	418	456	494	531	569	607	645	683	721	759	949
15	393	432	471	511	550	589	628	668	707	746	785	982
15½	406	446	487	528	568	609	649	690	730	771	812	1015
16	419	461	503	544	586	628	670	712	754	796	838	1047
16½	432	475	518	562	605	648	691	734	777	821	864	1080
17	445	490	534	579	623	668	712	757	801	846	890	1113
17½	458	504	550	596	641	687	733	779	825	870	916	1145
18	471	518	565	613	660	707	754	801	848	895	943	1178
18½	484	533	581	630	678	727	775	823	872	920	969	1211
19	497	547	597	647	696	746	796	846	895	945	995	1244
19½	511	562	613	664	715	766	817	868	919	970	1021	1276
20	524	576	628	681	733	785	838	890	943	995	1047	1309
21	550	605	660	715	770	825	880	935	990	1045	1100	1375
22	576	634	691	749	806	864	921	979	1037	1094	1152	1440
23	602	662	723	783	843	903	963	1024	1084	1140	1204	1505

DATA ON BELTS AND PULLEYS
(Continued)

VELOCITIES OF BELTS OR PULLEYS

Dia. of Pulley	Velocity of Belt or Pulley in Feet Per Minute when Number of Revolutions Per Minute Is 100	110	120	130	140	150	160	170	180	190	200	250
24	628	691	754	817	880	943	1005	1068	1131	1194	1257	1571
25	655	720	785	851	916	982	1047	1113	1178	1244	1309	1635
26	681	749	817	885	953	1021	1089	1157	1225	1293	1361	1702
27	707	778	848	919	990	1060	1131	1202	1272	1343	1414	1767
28	733	806	880	953	1026	1100	1173	1246	1319	1393	1466	1833
29	759	835	911	987	1063	1139	1215	1291	1366	1443	1518	1898
30	785	864	942	1021	1100	1178	1257	1335	1414	1492	1571	1964
31	812	893	974	1055	1136	1217	1299	1380	1461	1542	1623	2029
32	838	922	1005	1089	1173	1257	1340	1424	1508	1592	1676	2094
33	864	950	1037	1123	1210	1296	1382	1469	1555	1641	1728	2170
34	890	979	1068	1157	1264	1335	1424	1513	1602	1691	1780	2225
35	916	1008	1100	1191	1283	1375	1466	1558	1649	1741	1833	2291
36	943	1037	1131	1225	1320	1414	1508	1602	1697	1791	1885	2356
37	969	1066	1162	1259	1356	1452	1550	1646	1744	1840	1937	2421
38	995	1094	1194	1293	1393	1492	1592	1691	1791	1890	1990	2487
39	1021	1123	1225	1327	1429	1532	1634	1736	1838	1940	2042	2552
40	1047	1152	1257	1361	1466	1571	1676	1780	1885	1990	2094	2618
41	1073	1181	1288	1395	1503	1610	1718	1825	1932	2039	2147	2684
42	1100	1210	1319	1429	1539	1649	1759	1869	1979	2089	2199	2749
43	1126	1239	1351	1463	1576	1689	1801	1914	2026	2139	2252	2815
44	1152	1267	1382	1498	1613	1728	1843	1958	2073	2189	2304	2880
45	1178	1295	1414	1532	1650	1768	1885	2003	2120	2139	2356	2946
46	1204	1324	1445	1566	1686	1807	1927	2047	2167	2288	2409	3011
47	1231	1353	1477	1600	1723	1846	1969	2092	2214	2338	2461	3077
48	1257	1382	1508	1634	1759	1885	2011	2136	2262	2388	2513	3142
49	1283	1411	1539	1668	1796	1925	2053	2180	2309	2438	2565	3208
50	1309	1440	1571	1702	1833	1964	2094	2225	2356	2487	2618	3273
51	1335	1469	1602	1736	1870	2003	2136	2270	2403	2537	2670	3338
52	1361	1497	1634	1770	1906	2042	2178	2314	2450	2587	2723	3403
53	1388	1526	1665	1804	1943	2082	2220	2359	2497	2637	2775	3469
54	1414	1555	1696	1838	1979	2121	2262	2403	2545	2686	2827	3534
55	1440	1584	1728	1872	2016	2160	2304	2448	2592	2736	2879	3600
56	1466	1613	1759	1906	2053	2199	2346	2492	2639	2786	2932	3665
57	1492	1642	1791	1940	2090	2239	2388	2537	2686	2836	2984	3731
58	1518	1670	1822	1974	2126	2278	2429	2581	2733	2885	3037	3796
59	1545	1699	1854	2008	2163	2317	2471	2626	2780	2935	3090	3862
60	1571	1728	1885	2042	2199	2356	2513	2670	2827	2985	3142	3927
62	1623	1786	1948	2110	2273	2435	2597	2759	2922	3084	3246	4058
64	1676	1843	2011	2178	2346	2513	2681	2848	3016	3183	3351	4189
66	1728	1901	2074	2246	2419	2592	2765	2937	3110	3283	3456	4319

DATA ON BELTS AND PULLEYS
(Continued)

Velocities of Belts or Pulleys

Dia. of Pulley	Velocity of Belt or Pulley in Feet Per Minute when Number of Revolutions Per Minute Is 300	350	400	450	500	550	600	650	700	750	800	850
2	157	183	209	236	262	288	314	341	366	393	419	445
2½	196	229	262	295	327	360	393	425	458	491	524	556
3	236	275	314	353	393	432	471	511	550	589	628	668
3½	275	321	367	413	458	504	550	596	642	687	733	779
4	314	366	418	471	523	575	627	680	732	784	836	889
4½	353	412	471	530	589	648	707	766	825	883	942	1001
5	393	458	524	589	655	720	785	851	916	982	1047	1113
5½	432	504	576	648	720	792	864	936	1008	1080	1152	1224
6	471	550	628	707	786	864	943	1021	1100	1178	1257	1335
6½	510	595	680	765	851	936	1021	1106	1191	1276	1361	1445
7	550	642	733	824	916	1008	1100	1191	1282	1374	1466	1557
7½	589	687	785	883	982	1080	1178	1276	1374	1472	1570	1669
8	628	732	838	942	1047	1152	1256	1370	1466	1571	1675	1780
8½	668	779	890	1001	1113	1214	1335	1446	1558	1669	1780	1891
9	707	825	942	1060	1178	1296	1414	1531	1649	1767	1885	2003
9½	746	875	995	1119	1244	1368	1492	1617	1741	1865	1990	2114
10	785	916	1047	1178	1309	1440	1571	1702	1833	1964	2094	2225
10½	825	962	1100	1237	1375	1512	1649	1787	1924	2062	2199	2337
11	864	1008	1152	1296	1440	1584	1728	1872	2016	2160	2304	2448
11½	903	1054	1204	1355	1506	1656	1807	1957	2108	2258	2409	2559
12	942	1100	1256	1413	1571	1728	1885	2044	2199	2356	2513	2670
12½	982	1145	1309	1472	1636	1800	1963	2127	2290	2454	2618	2781
13	1022	1191	1362	1533	1703	1873	2044	2214	2384	2555	2725	2895
13½	1060	1237	1414	1590	1767	1944	2120	2297	2474	2651	2827	3004
14	1100	1282	1466	1649	1833	2016	2199	2382	2566	2749	2932	3115
14½	1139	1329	1518	1708	1898	2088	2278	2467	2657	2847	3037	3227
15	1178	1374	1571	1767	1964	2159	2356	2553	2749	2945	3142	3337
15½	1217	1420	1623	1826	2029	2233	2435	2638	2841	3044	3246	3449
16	1256	1466	1675	1885	2094	2303	2513	2722	2932	3142	3350	3560
16½	1296	1512	1728	1944	2160	2376	2591	2807	3023	3239	3455	3671
17	1335	1558	1780	2003	2226	2448	2671	2893	3116	3338	3561	3783
17½	1374	1603	1832	2061	2291	2520	2749	2978	3207	3436	3665	3894
18	1414	1649	1885	2120	2356	2592	2827	3063	3298	3534	3770	4005
18½	1453	1695	1937	2179	2422	2664	2906	3148	3390	3632	3874	4116
19	1492	1741	1990	2238	2487	2736	2984	3233	3482	3731	3979	4228
19½	1532	1787	2042	2297	2553	2808	3063	3318	3574	3829	4084	4339
20	1571	1833	2094	2356	2618	2880	3142	3403	3665	3927	4189	4451
21	1649	1924	2199	2474	2749	3021	3299	3574	3849	4123	4398	4673
22	1728	2016	2304	2592	2880	3168	3455	3743	4031	4319	4607	4895
23	1806	2108	2408	2709	3011	3312	3613	3914	4215	4516	4817	5118

DATA ON BELTS AND PULLEYS
(Continued)

VELOCITIES OF BELTS OR PULLEYS

Dia. of Pulley	Velocity of Belt or Pulley in Feet Per Minute when Number of Revolutions Per Minute Is											
	300	350	400	450	500	550	600	650	700	750	800	850
24	1885	2199	2513	2827	3142	3456	3770	4084	4398	4712	5027	5341
25	1964	2290	2618	2945	3273	3600	3927	4254	4582	4909	5236	....
26	2042	2384	2723	3063	3404	3744	4084	4425	4765	5205	....	....
27	2120	2474	2827	3181	3534	3887	4241	4594	4948	5301	....	....
28	2199	2566	2932	3299	3665	4032	4398	4765	5131	....	....	....
29	2278	2657	3037	3416	3796	4176	4555	4935	5314	....	....	....
30	2356	2749	3142	3534	3927	4320	4712	5105	....	....	....	....
31	2435	2841	3246	3652	4058	4464	4870	5275	....	....	....	....
32	2513	2932	3351	3770	4189	4607	5026	....	....	....	....	....
33	2592	3023	3456	3887	4320	4751	5184	....	....	....	....	....
34	2670	3116	3560	4005	4451	4896	....	....	....	....	....	....
35	2749	3207	3665	4123	4582	5040	....	....	....	....	....	....
36	2828	3298	3770	4241	4713	5184	....	....	....	....	....	....

Dia. of Pulley	Velocity of Belt or Pulley in Feet Per Minute when Revolutions Per Minute Is											
	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
2	471	524	576	628	681	733	785	838	890	943	993	1046
2½	589	655	720	785	851	916	981	1046	1112	1178	1244	1309
3	707	785	864	943	1021	1100	1178	1257	1335	1414	1492	1571
3½	825	916	1008	1100	1192	1283	1375	1467	1558	1650	1740	1832
4	941	1046	1151	1255	1359	1464	1568	1673	1777	1882	1989	2094
4½	1060	1178	1296	1414	1531	1649	1767	1885	2003	2120	2238	2356
5	1178	1309	1440	1571	1702	1833	1964	2094	2225	2356	2487	2618
5½	1296	1440	1584	1728	1872	2016	2160	2304	2448	2592	2736	2880
6	1414	1571	1728	1885	2042	2199	2357	2514	2671	2828	2984	3142
6½	1531	1702	1871	2041	2211	2381	2552	2722	2892	3062	3235	3406
7	1649	1832	2015	2198	2382	2564	2748	2931	3114	3298	3482	3665
7½	1777	1963	2159	2356	2552	2748	2945	3141	3337	3533	3731	3927
8	1885	2094	2303	2513	2722	2932	3142	3350	3560	3769	3979	4188
8½	2003	2225	2448	2670	2893	3115	3338	3561	3782	4005	4228	4451
9	2120	2356	2592	2827	3063	3298	3534	3770	1005	4241	4476	4712
9½	2238	2487	2735	2984	3233	3482	3731	3979	4228	4477	4725	4974
10	2356	2618	2880	3142	3403	3665	3927	4189	4451	4712	4974	5236

DATA ON BELTS AND PULLEYS
(Continued)

ANGLE OF CONTACT

Difference in diameters of pulleys (inches)	Distance between centers of pulleys in inches when angle of contact on smaller pulley is 120°	125°	130°	135°	140°	145°	150°	155°	160°	165°	170°	175°
1	..	....	....	....	....	....	....	....	....	....	....	11.5
2	..	....	....	....	....	....	....	....	....	....	11.5	23
3	..	....	....	....	....	....	....	....	....	11.5	17.2	34.5
4	..	....	....	....	....	....	....	....	11.5	15.3	22.9	46.
5	..	....	....	....	....	....	....	11.6	14.4	19.2	28.7	57.4
6	..	....	....	....	....	....	11.6	13.8	17.3	23.0	34.4	68.7
7	..	....	....	....	....	11.6	13.6	15.1	20.2	26.8	40.2	79.2
8	..	....	....	....	11.6	13.3	15.5	18.5	23.0	30.6	45.9	91.7
9	..	....	....	11.8	13.1	14.9	17.4	20.8	25.9	34.4	51.6	103.1
10	..	....	11.8	13.1	14.6	16.6	19.3	23.1	28.8	38.2	57.4	114.5
11	..	11.9	13.0	14.4	16.1	18.3	21.2	25.4	31.7	42.1	63.1	125.9
12	12	13.0	14.2	15.7	17.5	19.9	23.2	27.7	34.5	45.9	69.8	137.4
13	13	14.1	15.4	17.0	18.9	21.6	25.1	30.1	37.4	49.7	74.6	148.4
14	14	15.2	16.6	18.3	20.4	23.3	27.0	32.4	40.3	53.6	80.3	160.3
15	15	16.3	17.8	19.7	21.8	24.9	29.0	34.7	43.2	57.4	86.1	171.7
16	16	17.4	19.0	21.0	23.3	26.6	30.9	37.0	46.1	61.2	91.8	183.2
17	17	18.4	20.1	22.2	24.8	28.3	32.8	39.3	48.9	65.1	97.5	194.6
18	18	19.5	21.3	23.5	26.2	29.9	34.8	41.6	51.8	68.9	103.3	205.1
19	19	20.6	22.5	24.8	27.7	31.6	36.7	43.9	54.7	72.7	109.0	217.5
20	20	21.7	23.7	26.1	29.2	33.3	38.6	46.2	57.6	76.6	114.7	229.0
21	21	22.8	24.9	27.4	30.7	35.0	40.5	48.5	60.5	80.4	120.5	240.4
22	22	23.9	26.2	28.7	32.1	36.6	42.5	50.8	63.4	84.2	126.2	251.9
23	23	24.9	27.4	30.0	33.6	38.3	44.4	53.1	66.3	88.1	132.0	263.3
24	24	26.0	28.5	31.3	35.1	40.0	46.3	55.4	69.1	91.9	137.7	274.8
25	25	27.1	29.7	32.7	36.5	41.6	48.3	57.7	72.0	95.7	143.4	286.2
26	26	28.2	30.9	34.0	38.0	43.3	50.2	60.1	74.9	99.6	149.2	297.7
27	27	29.3	32.1	35.3	39.5	45.0	52.1	62.4	77.7	103.4	154.9	309.1
28	28	30.3	33.3	36.6	40.9	46.5	54.1	64.7	80.6	107.2	160.6	320.6
29	29	31.4	34.4	37.9	42.4	48.2	56.0	67.0	83.5	111.0	166.4	332.0
30	30	32.5	35.6	39.2	43.9	49.8	57.9	69.3	86.4	114.9	172.1	343.5
31	31	33.6	36.8	40.5	45.3	51.5	59.9	71.6	89.3	118.7	177.8	.....
32	32	34.6	38.0	41.8	46.8	53.2	61.8	73.9	92.2	122.5	183.6	.....
33	33	35.7	39.2	43.1	48.3	54.8	63.7	76.2	95.1	126.4	189.3	.....
34	34	36.8	40.3	44.4	49.7	56.5	65.7	78.5	97.9	130.2	195.1	.....
35	35	37.9	41.5	45.8	51.2	58.2	67.6	80.8	100.8	134.0	200.8	.....
36	36	39.0	42.7	47.1	52.7	59.8	69.5	83.2	103.7	137.8	206.5	.....
37	37	40.0	43.9	48.4	54.1	61.5	71.5	85.5	106.5	141.7	212.3	.....
38	38	41.1	45.1	49.7	55.6	63.2	73.4	87.8	109.4	145.5	218.0	.....
39	39	42.2	46.2	51.0	57.0	64.8	75.3	90.1	112.3	149.3	223.7	.....
40	40	43.3	47.3	52.3	58.5	66.5	77.3	92.4	115.2	153.2	229.4	.....

DATA ON BELTS AND PULLEYS
(Continued)

ANGLE OF CONTACT

Difference in diameters of pulleys (inches)	Distance between centers of pulleys in inches when angle of contact on smaller pulley is 120°	125°	130°	135°	140°	145°	150°	155°	160°	165°	170°
41	41	44.3	48.5	53.6	60.0	68.2	79.2	94.7	118.1	157.0	235.2
42	42	45.4	49.7	54.9	61.4	69.8	81.1	97.0	121.0	160.9	241.0
43	43	46.5	50.9	56.2	62.9	71.5	83.1	99.3	123.9	164.8	246.7
44	44	47.6	52.0	57.5	64.3	73.2	85.0	101.6	126.8	168.6	252.4
45	45	48.7	53.2	58.8	65.8	74.8	86.9	104.0	129.7	172.5	258.2
46	46	49.8	54.4	60.1	67.3	76.5	88.9	106.3	132.6	176.3	263.9
47	47	50.9	55.6	61.4	68.7	78.2	90.8	108.6	135.4	180.1	269.6
48	48	52.0	56.8	62.7	70.2	79.8	92.7	110.9	138.3	183.9	275.4
49	49	53.1	58.0	64.0	71.6	81.5	94.7	113.2	141.2	187.7	281.1
50	50	54.2	59.2	65.3	73.1	83.2	96.6	115.5	144.1	191.5	286.9
51	51	55.2	60.3	66.7	74.6	84.8	98.5	117.8	147.0	195.4	292.6
52	52	56.3	61.5	68.0	76.0	86.5	100.5	120.2	149.9	199.2	298.3
53	53	57.4	62.7	69.3	77.5	88.2	102.4	122.5	152.8	203.0	304.1
54	54	58.5	63.9	70.6	78.9	89.8	104.3	124.8	155.7	206.9	309.8
55	55	59.6	65.1	71.9	80.4	91.5	106.3	127.1	158.5	210.7	315.5
56	56	60.7	66.3	73.2	81.9	93.2	108.2	129.4	161.4	214.5	321.3
57	57	61.7	67.4	74.5	83.3	94.8	110.1	131.7	164.2	218.4	327.0
58	58	62.8	68.6	75.8	84.8	96.5	112.1	134.0	167.1	222.2	332.7
59	59	63.9	69.8	77.1	86.2	98.2	114.0	136.3	170.0	226.0	338.5
60	60	65.0	71.0	78.4	87.7	99.8	115.9	138.6	172.8	229.8	344.2
61	61	66.1	72.2	79.7	89.2	101.5	117.9	140.9	175.7	233.7	.....
62	62	67.2	73.4	81.0	90.7	103.2	119.8	143.3	178.6	237.5	.....
63	63	68.2	74.5	82.3	92.1	104.8	121.7	145.6	181.4	241.3	.....
64	64	69.3	75.7	83.6	93.6	106.5	123.7	147.9	184.3	245.2	.....
65	65	70.4	76.9	84.9	95.1	108.2	125.6	150.2	187.2	249.0	.....
66	66	71.5	78.1	86.2	96.5	109.8	127.5	152.5	190.1	252.8	.....
67	67	72.6	79.3	87.5	98.0	111.4	129.5	154.8	192.9	256.6	.....
68	68	73.6	80.4	88.8	99.5	113.1	131.4	157.1	195.8	260.5	.....
69	69	74.7	81.6	90.1	100.9	114.7	133.3	159.4	198.7	264.3	.....
70	70	75.8	82.8	91.5	102.4	116.4	135.2	161.7	201.6	268.1	.....
71	71	76.9	84.0	92.8	103.8	118.0	137.1	164.0	204.5	271.9	.....
72	72	78.0	85.2	94.1	105.3	119.7	139.0	166.3	207.4	275.8	.....
74	74	80.1	87.5	96.7	108.2	123.0	142.8	170.9	213.1	283.4	.....
76	76	82.3	89.9	99.3	111.2	126.3	146.7	175.5	218.9	291.1	.....
78	78	84.4	92.2	101.9	114.1	129.7	150.6	180.2	224.6	298.7	.....
80	80	86.6	94.6	104.5	117.0	133.0	154.5	184.8	230.4	306.4	.....
82	82	88.8	97.0	107.1	119.9	136.3	158.4	189.4	236.2	314.1	.....
84	84	90.9	99.3	109.7	122.8	139.7	162.2	194.0	241.9	321.7	.....
86	86	93.1	101.7	112.3	125.8	143.0	166.1	198.6	247.7	329.3	.....
88	88	95.3	104.0	115.0	128.7	146.3	170.0	203.3	253.4	337.0	.....

DATA ON BELTS AND PULLEYS
(Continued)

Horsepower Transmitted by Belts

The horsepower transmitted by a belt depends upon the velocity of the belt (see pages 67 to 70), the angle of contact of the belt on the smaller pulley and the area of belt cross section.

The angle of contact is found on pages 71 and 72, as follows: On the line headed by the difference between the given pulley diameters find the distance between centers which is the nearest one below the given distance between centers. Then the angle at the top of the column will be the required angle. For example, suppose the given pulley diameters are 9 inches and 27 inches and the distance between centers is 60 inches. Then the difference between diameters is 18 inches. In the table on the line opposite 18 inches it is noted that 60 inches lies between the two given distances 51.8 and 68.9. The smaller distance is 51.8 and as the column, in which it lies is that for 160 degrees, the angle of contact is 160 degrees. This does not give the exact angle, but is a close approximation.

The horsepower per square inch of belt area is found by using data on pages 74 and 75, using angle of contact found as above and velocity of belt in tables on pages 67 to 70. For instance, if the given pulley is 27 inches in diameter running at 250 revolutions per minute we find from page 68 that the velocity of belt is 1767. The nearest to this in the horsepower table is 1750 and with an angle of contact of 160 degrees, the horsepower per square inch of belt cross section would be 7.74.

The horsepower transmitted by a given belt is found by multiplying the cross section area by the horsepower per square inch.

The area required for a given horsepower is found by dividing the given horsepower by the horsepower per square inch.

DATA ON BELTS AND PULLEYS
(Continued)

HORSEPOWER PER SQUARE INCH OF BELT SECTION, BASED ON BARTH'S FORMULA

Velocity of belt, ft. per min.	Horsepower per sq. in. of belt section when angle of contact of belt with smaller pulley is 180°	175°	170°	165°	160°	155°	150°	145°	140°	135°	130°	125°	120°
250	1.05	1.03	1.00	.98	.96	.94	.92	.90	.87	.84	.82	.80	.77
300	1.29	1.27	1.24	1.21	1.18	1.16	1.13	1.11	1.07	1.04	1.01	.98	.95
350	1.53	1.51	1.48	1.44	1.40	1.38	1.34	1.32	1.27	1.24	1.20	1.17	1.13
400	1.77	1.75	1.71	1.67	1.63	1.60	1.56	1.53	1.48	1.44	1.39	1.36	1.31
450	2.02	1.99	1.94	1.90	1.86	1.82	1.78	1.74	1.69	1.64	1.59	1.55	1.49
500	2.27	2.23	2.18	2.14	2.09	2.04	2.00	1.95	1.90	1.85	1.79	1.74	1.68
550	2.52	2.47	2.42	2.38	2.32	2.29	2.22	2.17	2.11	2.06	2.00	1.94	1.88
600	2.77	2.72	2.66	2.62	2.55	2.54	2.44	2.39	2.32	2.27	2.21	2.14	2.08
650	3.02	2.97	2.90	2.86	2.79	2.78	2.66	2.51	2.54	2.48	2.42	2.34	2.27
700	3.28	3.22	3.15	3.10	3.03	3.00	2.89	2.73	2.76	2.69	2.62	2.54	2.46
750	3.53	3.47	3.40	3.34	3.27	3.20	3.12	3.05	2.98	2.90	2.82	2.75	2.65
800	3.78	3.71	3.65	3.57	3.50	3.42	3.34	3.26	3.19	3.10	3.02	2.93	2.85
850	4.03	3.95	3.89	3.80	3.73	3.65	3.56	3.48	3.40	3.31	3.22	3.13	3.04
900	4.28	4.20	4.13	4.04	3.96	3.88	3.78	3.70	3.61	3.52	3.42	3.32	3.23
950	4.53	4.50	4.37	4.28	4.19	4.11	4.01	3.92	3.82	3.73	3.62	3.52	3.42
1000	4.78	4.70	4.61	4.52	4.43	4.34	4.24	4.14	4.04	3.94	3.83	3.72	3.61
1050	5.03	4.95	4.85	4.76	4.67	4.56	4.46	4.36	4.25	4.14	4.03	3.91	3.80
1100	5.28	5.19	5.09	5.00	4.90	4.79	4.68	4.58	4.46	4.35	4.23	4.11	3.99
1150	5.52	5.43	5.33	5.24	5.13	5.02	4.90	4.80	4.68	4.56	4.43	4.31	4.18
1200	5.77	5.67	5.57	5.47	5.36	5.25	5.13	5.02	4.90	4.77	4.64	4.51	4.37
1250	6.01	5.91	5.80	5.69	5.58	5.46	5.34	5.32	5.11	4.97	4.84	4.70	4.56
1300	6.25	6.15	6.03	5.91	5.80	5.68	5.55	5.44	5.31	5.17	5.04	4.89	4.75
1350	6.49	6.38	6.26	6.14	6.02	5.90	5.77	5.65	5.51	5.37	5.23	5.08	4.93
1400	6.72	6.61	6.49	6.37	6.25	6.12	5.99	5.85	5.71	5.57	5.42	5.27	5.11
1450	6.95	6.84	6.72	6.59	6.48	6.34	6.19	6.06	5.91	5.77	5.61	5.46	5.29
1500	7.18	7.07	6.94	6.81	6.70	6.55	6.40	6.27	6.11	5.97	5.80	5.65	5.47
1550	7.41	7.29	7.16	7.03	6.91	6.76	6.61	6.47	6.31	6.16	5.99	5.83	5.65
1600	7.64	7.51	7.38	7.25	7.11	6.97	6.82	6.67	6.51	6.35	6.18	6.01	5.83
1650	7.87	7.73	7.60	7.46	7.32	7.18	7.02	6.87	6.70	6.54	6.37	6.19	6.01
1700	8.09	7.95	7.82	7.67	7.53	7.38	7.22	7.07	6.89	6.72	6.55	6.37	6.19
1750	8.31	8.17	8.03	7.88	7.74	7.58	7.42	7.26	7.08	6.90	6.73	6.55	6.36
1800	8.53	8.39	8.24	8.09	7.94	7.78	7.62	7.45	7.27	7.08	6.91	6.72	6.53
1850	8.74	8.60	8.45	8.29	8.14	7.98	7.81	7.64	7.45	7.25	7.08	6.89	6.69
1900	8.95	8.81	8.65	8.49	8.34	8.17	8.00	7.82	7.63	7.42	7.25	7.06	6.85
1950	9.16	9.01	8.85	8.69	8.53	8.36	8.19	8.00	7.81	7.60	7.42	7.22	7.01
2000	9.36	9.20	9.05	8.89	8.72	8.55	8.37	8.18	7.99	7.79	7.59	7.38	7.17
2050	9.54	9.38	9.22	9.06	8.89	8.70	8.53	8.34	8.14	7.94	7.74	7.52	7.31
2100	9.72	9.56	9.39	9.32	9.06	8.86	8.69	8.50	8.29	8.09	7.89	7.66	7.45
2150	9.90	9.74	9.57	9.40	9.23	9.02	8.85	8.66	8.45	8.24	8.04	7.80	7.59

DATA ON BELTS AND PULLEYS
(*Continued*)

HORSEPOWER PER SQUARE INCH OF BELT SECTION BASED ON BARTH'S FORMULA

Velocity of belt, ft. per min.	Horsepower per sq. in. of belt section when angle of contact of belt on smaller pulley is												
	180°	175°	170°	165°	160°	155°	150°	145°	140°	135°	130°	125°	120°
2200	10.08	9.92	9.75	9.57	9.40	9.19	9.01	8.82	8.61	8.39	8.19	7.95	7.73
2250	10.26	10.10	9.93	9.74	9.57	9.36	9.17	8.98	8.77	8.54	8.34	8.10	7.87
2300	10.44	10.28	10.11	9.92	9.74	9.53	9.34	9.14	8.93	8.69	8.49	8.25	8.01
2350	10.63	10.46	10.29	10.10	9.91	9.70	9.51	9.30	9.09	8.85	8.64	8.40	8.15
2400	10.82	10.64	10.47	10.28	10.09	9.88	9.68	9.47	9.25	9.01	8.79	8.55	8.30
2450	11.01	10.83	10.65	10.46	10.27	10.06	9.85	9.64	9.41	9.17	8.94	8.70	8.45
2500	11.20	11.02	10.83	10.64	10.44	10.23	10.02	9.80	9.57	9.33	9.10	8.85	8.60
2550	11.34	11.16	10.96	10.75	10.57	10.36	10.14	9.92	9.69	9.45	9.21	8.96	8.71
2600	11.48	11.30	11.09	10.88	10.70	10.49	10.27	10.04	9.81	9.57	9.32	9.07	8.82
2650	11.62	11.44	11.23	11.01	10.83	10.62	10.40	10.16	9.93	9.69	9.43	9.18	8.93
2700	11.76	11.58	11.37	11.14	10.96	10.75	10.53	10.28	10.05	9.81	9.55	9.29	9.04
2750	11.90	11.72	11.51	11.27	11.09	10.88	10.66	10.41	10.17	9.93	9.67	9.40	9.15
2800	12.04	11.86	11.65	11.41	11.22	11.01	10.79	10.54	10.29	10.05	9.79	9.51	9.26
2850	12.18	12.00	11.79	11.55	11.35	11.14	10.92	10.67	10.42	10.17	9.91	9.63	9.37
2900	12.32	12.14	11.93	11.69	11.49	11.27	11.05	10.80	10.55	10.29	10.03	9.75	9.48
2950	12.47	12.28	12.07	11.84	11.63	11.40	11.18	10.93	10.68	10.41	10.15	9.87	9.59
3000	12.62	12.42	12.21	11.99	11.77	11.54	11.31	11.06	10.81	10.54	10.27	9.99	9.71
3050	12.70	12.51	12.30	12.08	11.85	11.63	11.40	11.14	10.89	10.62	10.35	10.06	9.78
3100	12.80	12.60	12.39	12.17	11.92	11.71	11.48	11.22	10.97	10.70	10.42	10.13	9.85
3150	12.88	12.69	12.47	12.25	12.00	11.80	11.56	11.30	11.05	10.78	10.50	10.20	9.92
3200	12.96	12.78	12.56	12.32	12.09	11.87	11.64	11.38	11.13	10.86	10.57	10.27	9.99
3300	13.14	12.96	12.73	12.49	12.24	12.04	11.80	11.54	11.28	11.01	10.72	10.42	10.13
3400	13.32	13.13	12.90	12.67	12.42	12.21	11.96	11.70	11.43	11.16	10.87	10.57	10.27
3500	13.51	13.30	13.08	12.85	12.61	12.37	12.12	11.86	11.59	11.31	11.02	10.72	10.41
3600	13.56	13.36	13.13	12.90	12.66	12.42	12.17	11.92	11.64	11.36	11.07	10.76	10.46
3700	13.62	13.42	13.19	12.95	12.71	12.47	12.22	11.97	11.69	11.41	10.12	10.81	10.51
3800	13.68	13.48	13.25	13.01	12.77	12.52	12.27	12.02	11.74	11.46	11.17	10.86	10.56
3900	13.74	13.54	13.31	13.07	12.83	12.58	12.33	12.07	11.79	11.51	11.22	10.91	10.61
4000	13.80	13.59	13.37	13.13	12.89	12.64	12.39	12.12	11.85	11.56	11.26	10.96	10.65
4100	13.72	13.51	13.29	13.05	12.81	12.56	12.31	12.05	11.78	11.49	11.19	10.90	10.59
4200	13.64	13.43	13.21	12.97	12.73	12.49	12.24	11.98	11.71	11.42	11.12	10.84	10.53
4300	13.56	13.35	13.13	12.89	12.66	12.42	12.17	11.91	11.64	11.35	11.06	10.78	10.47
4400	13.48	13.27	13.05	12.82	12.59	12.35	12.10	11.84	11.57	11.28	11.00	10.71	10.41
4500	13.40	13.13	12.97	12.75	12.52	12.28	12.03	11.77	11.50	11.22	10.94	10.64	10.35
4600	13.14	12.91	12.73	12.53	12.29	12.05	11.81	11.56	11.28	11.02	10.74	10.45	10.16
4700	12.90	12.68	12.50	12.30	12.06	11.82	11.59	11.35	11.08	10.82	10.54	10.26	9.97
4800	12.66	12.45	12.27	12.07	11.82	11.59	11.38	11.14	10.88	10.62	10.35	10.07	9.79
4900	12.42	12.23	12.04	11.84	11.61	11.36	11.17	10.93	10.68	10.42	10.16	9.88	9.61
5000	12.20	12.01	11.81	11.61	11.40	11.13	10.96	10.72	10.48	10.22	9.97	9.70	9.43

DATA ON BELTS AND PULLEYS

(Continued)

Area of Belt Section

Width of belt in inches	Area of belt when thickness in inches is 1/8	1/6	3/16	1/4	9/32	5/16	1/3	3/8	7/16	1/2	9/16	5/8	11/16
	.125	.167	.188	.250	.281	.313	.333	.375	.438	.500	.563	.625	.688
1½	.188	.250	.281	.375	.422	.469	.500	.563	.656	.750	.844	.938	1.03
2	.250	.333	.375	.500	.563	.625	.667	.750	.875	1.00	1.13	1.25	1.38
2½	.313	.417	.468	.625	.703	.781	.833	.938	1.09	1.25	1.41	1.56	1.72
3	.375	.500	.563	.750	.844	.938	1.00	1.13	1.31	1.50	1.69	1.88	2.06
3½	.438	.583	.656	.875	.984	1.08	1.17	1.31	1.53	1.75	1.97	2.19	2.41
4	.500	.667	.750	1.00	1.13	1.25	1.33	1.50	1.75	2.00	2.25	2.50	2.75
4½	.563	.750	.844	1.13	1.27	1.41	1.50	1.69	1.97	2.25	2.53	2.81	3.09
5	.625	.833	.938	1.25	1.41	1.56	1.67	1.88	2.18	2.50	2.81	3.13	3.44
5½	.688	.917	1.03	1.37	1.55	1.72	1.83	2.06	2.41	2.75	3.09	3.44	3.78
6	.750	1.00	1.13	1.50	1.69	1.88	2.00	2.25	2.63	3.00	3.38	3.75	4.13
6½	.813	1.08	1.22	1.63	1.83	2.03	2.17	2.44	2.84	3.25	3.66	4.06	4.47
7	.875	1.17	1.31	1.75	1.97	2.18	2.33	2.63	3.06	3.50	3.94	4.38	4.81
7½	.938	1.25	1.41	1.88	2.11	2.34	2.50	2.81	3.28	3.75	4.22	4.69	5.16
8	1.00	1.33	1.50	2.00	2.25	2.50	2.67	3.00	3.50	4.00	4.50	5.00	5.50
8½	1.06	1.42	1.59	2.13	2.39	2.66	2.83	3.18	3.72	4.25	4.78	5.31	5.84
9	1.13	1.50	1.69	2.25	2.53	2.81	3.00	3.38	3.94	4.50	5.06	5.63	6.19
9½	1.19	1.58	1.78	2.37	2.67	2.97	3.17	3.56	4.16	4.75	5.34	5.94	6.53
10	1.25	1.67	1.88	2.50	2.81	3.13	3.33	3.75	4.38	5.00	5.62	6.25	6.88
11	1.38	1.83	2.06	2.75	3.09	3.44	3.67	4.13	4.81	5.50	6.19	6.88	7.56
12	1.50	2.00	2.25	3.00	3.38	3.75	4.00	4.50	5.25	6.00	6.75	7.50	8.25
13	1.63	2.17	2.44	3.25	3.66	4.06	4.33	4.88	5.68	6.50	7.31	8.13	8.94
14	1.75	2.33	2.63	3.50	3.94	4.38	4.67	5.25	6.13	7.00	7.88	8.75	9.63
15	1.88	2.50	2.81	3.75	4.22	4.69	5.00	5.63	6.56	7.50	8.44	9.38	10.31
16	2.00	2.67	3.00	4.00	4.50	5.00	5.33	6.00	7.00	8.00	9.00	10.00	11.00
17	2.13	2.83	3.19	4.25	4.78	5.31	5.67	6.38	7.44	8.50	9.56	10.63	11.69
18	2.25	3.00	3.38	4.50	5.06	5.63	6.00	6.75	7.88	9.00	10.13	11.25	12.38
19	2.37	3.17	3.56	4.75	5.34	5.94	6.33	7.13	8.31	9.50	10.69	11.88	13.06
20	2.50	3.33	3.75	5.00	5.62	6.25	6.67	7.50	8.75	10.00	11.25	12.50	13.75
22	2.75	3.67	4.13	5.50	6.19	6.88	7.33	8.25	9.63	11.00	12.38	13.75	15.13
24	3.00	4.00	4.50	6.00	6.75	7.50	8.00	9.00	10.50	12.00	13.50	15.00	16.50
26	3.25	4.33	4.88	6.50	7.31	8.13	8.67	9.75	11.38	13.00	14.63	16.25	17.88
28	3.50	4.67	5.25	7.00	7.88	8.75	9.33	10.50	12.25	14.00	15.75	17.50	19.25
30	3.75	5.00	5.63	7.50	8.44	9.38	10.00	11.25	13.13	15.00	16.88	18.75	20.63
32	4.00	5.33	6.00	8.00	9.00	10.00	10.67	12.00	14.00	16.00	18.00	20.00	22.00
34	4.25	5.67	6.38	8.50	9.56	10.63	11.33	12.75	14.88	17.00	19.13	21.25	23.38
36	4.50	6.00	6.75	9.00	10.13	11.25	12.00	13.50	15.75	18.00	20.25	22.50	24.75
40	5.00	6.67	7.50	10.00	11.25	12.50	13.33	15.00	17.50	20.00	22.50	25.00	27.50
44	5.50	7.33	8.25	11.00	12.38	13.75	14.67	16.50	19.25	22.00	24.75	27.50	30.25

For method of use, see preceding data sheets.

DATA ON BELTS AND PULLEYS
(Continued)

Size of Belts

If the required horsepower is given, from the information already presented the cross sectional area required may be obtained. For this area different thicknesses or widths may be chosen, the other dimension depending upon these factors.

If the width of pulley is given, then the belt width is obtained from table following. Then note this width in the first column on page 76. Opposite this find the area nearest to the area required, and at the top of the column will be the required thickness.

Width of Pulley	Width of Belt
1½ to 3½ inches	width of pulley minus ½ inch
4 to 6¾ inches	width of pulley minus ¾ inch
7½ to 13 inches	width of pulley minus 1 inch
14 to 24½ inches	width of pulley minus 1½ inches
26 to 40 inches	width of pulley minus 2 inches
42 inches and above	width of pulley minus 3 inches

Another condition affecting the size of belt is the diameter of the smaller pulley as a thick belt running over a small pulley will crack. Therefore a double belt should not be used on a pulley less than 10-inch diameter or a three-ply belt on a pulley less than 18 inches in diameter. The thickness of a single ply belt is approximately 1/6 inch, of standard double 1/3 inch, and of three-ply belt 9/16 inch.

If the pulley width is not given, then the dimensions of the belt may be chosen and the pulley width made to suit. In this case the thickest standard belt possible is chosen, that is, single belts for pulleys under 10-inch diameter, double belt for pulley 10-inch diameter up to 18-inch diameter, and three-ply belts for pulleys 18-inch diameter and up, as narrow thick belts are more durable than wide thin belts. The width of belt is then determined from the cross sectional area table, using the thickness chosen and the area required for given horsepower.

DATA ON BELTS AND PULLEYS
(*Concluded*)

Width of Pulley

The width of pulley should be greater than the belt width by the following amounts:

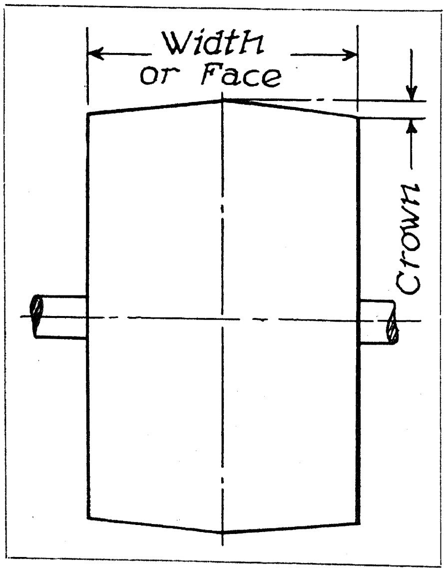
Width of Belt	Width of Pulley
1 to 3 inches	Width of belt plus ½ inch
3¼ to 6 inches	Width of belt plus ¾ inch
6½ to 12 inches	Width of belt plus 1 inch
13 to 23 inches	Width of belt plus 1½ inches
24 to 38 inches	Width of belt plus 2 inches
39 inches and above	Width of belt plus 3 inches

Economical Speed for Belting

The most economical speed of belting is between 4000 and 4500 feet per minute.

Direction of Belt

The thin edge of all laps and splices on the side of the belt next pulley should point away from the pulley which the belt is approaching. The hair side of the belt should run next to the pulley.



Crowns for Pulleys

Width or Face (Inches)	Crown (Inches)
2 to 2½ inclusive	1/32
3 to 5 inclusive	1/16
5½ to 8 inclusive	3/32
9 to 12 inclusive	1/8
13 to 20 inclusive	5/32
21 to 28 inclusive	3/16
29 to 40 inclusive	1/4
41 to 50 inclusive	9/32

Arrangement for Pulleys

Machinery driven from overhead shafts should be so placed that the belt will make an angle from the vertical of not less than 45 degrees. The driving and driven pulleys never should be in the same vertical line, if it is possible to secure other arrangement.

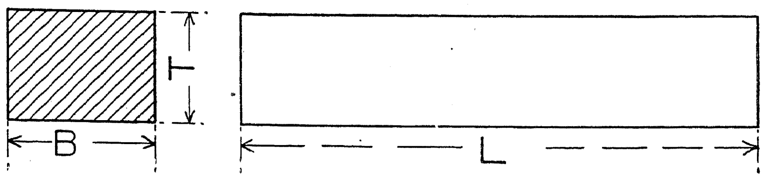
SECTION II

COMPUTING WEIGHTS

FORMULAS FOR FINDING WEIGHTS OF IRON CASTINGS

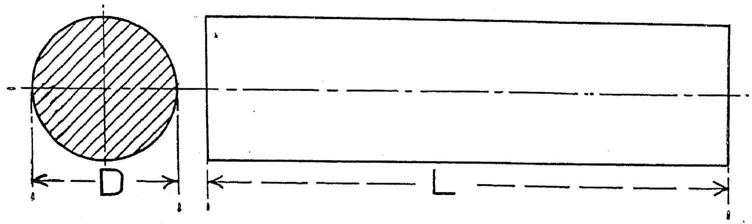
To find the weight of square or rectangular castings, multiply the length, by the breadth, by the thickness, by 0.26.

$$W = L\ B\ T \times 0.26$$



To find the weight of solid cylinders, the weight equals the outside diameter squared, multiplied by the length, multiplied by 0.204.

$$W = D^2\ L \times 0.204$$

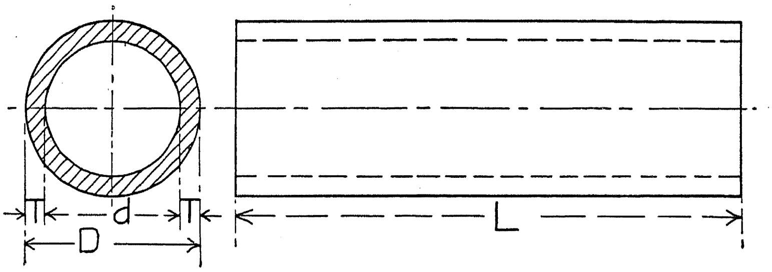


W=Weight of casting in pounds.
L=Length of casting in inches.
T=Thickness of casting in inches.
B=Breadth of casting in inches.
D=Outside or large diameter in inches.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)

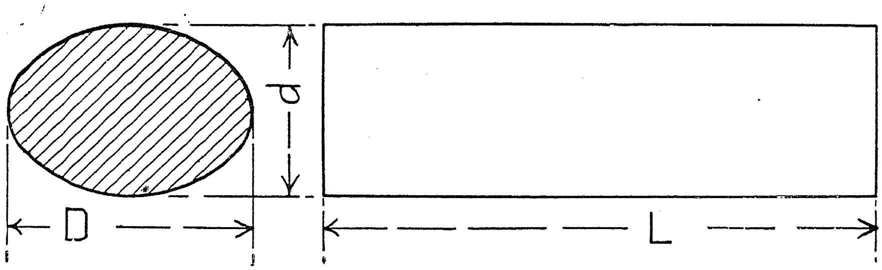
To find the weight of hollow cylinders, multiply the small or inside diameter plus the thickness, by the length, by the thickness, by 0.817.

$$W = (d + T)\ T\ L \times 0.817$$



To find the weight of a solid ellipse, multiply the large diameter by the small diameter, by the length, by 0.204.

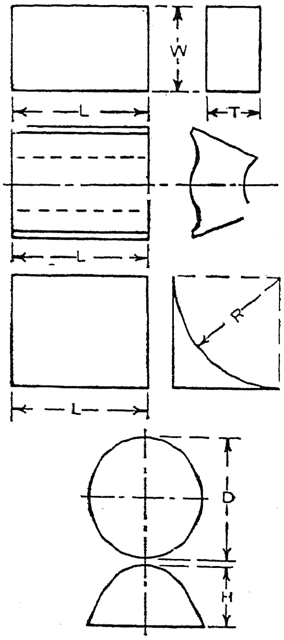
$$W = D\ d\ L \times 0.204$$



W=Weight of casting in pounds.
L=Length of casting in inches.
T=Thickness of casting in inches.
D=Outside or large diameter in inches.
d=Inside or small diameter in inches.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS

(Continued)



To find the weight of a solid rectangular casting, multiply the length by the width, by the thickness, by the weight per cubic inch of material used.

Weight$=L\ W\ T \times Wt.$ per cu. in.

To find the weight of a bar of irregular cross-section, multiply the area of the cross-section by the length, by the weight per cubic inch of material used.

Weight$=$Area $\times L \times Wt.$ per cu. in.

To find the weight of a straight fillet of any material, multiply the radius squared by the length, by the constant, K, corresponding to the weight per cubic inch.

Weight$=R^2\ L\ K$

To find the weight of a paraboloid, multiply the diameter of the base squared by the height by the constant, m, whose value is indicated on page 83.

Weight$=D^2 H\ m$

Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K
.096	.0206	.150	.0322	.210	.0451	.270	.0580	.330	.0708	.390	.0837	.450	.0966	.510	.1094
.100	.0215	.160	.0343	.220	.0472	.280	.0601	.340	.0730	.400	.0858	.460	.0987	.520	.1116
.110	.0236	.170	.0365	.230	.0494	.290	.0622	.350	.0751	.410	.0880	.470	.1009	.530	.1138
.120	.0258	.180	.0387	.240	.0515	.300	.0644	.360	.0773	.420	.0901	.480	.1030	.540	.1159
.130	.0279	.190	.0408	.250	.0536	.310	.0665	.370	.0794	.430	.0923	.490	.1052	.550	.1180
.140	.0300	.200	.0429	.260	.0558	.320	.0687	.380	.0815	.440	.0944	.500	.1073	.560	.1202

If the weight, per cubic inch of material used, lies between two of the weights given above, use the interpolation table as follows:

Subtract the lowest of the two weights from that required; add the additional value of K, corresponding to this difference, called additional weight, to the value of K, for the least of two weights, between which the required weight lies.

Required K for material, which weighs .326 pound per cubic inch. This lies between .320 and .330. Subtracting the lowest (.320) from .326 we have .006 additional value of K, for $.006 = .0013$

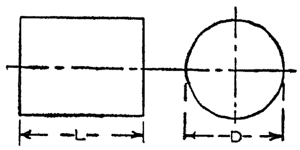
value of K, for $.320 = .0687$

value of K, for $.326 = .0800$

INTERPOLATION TABLE

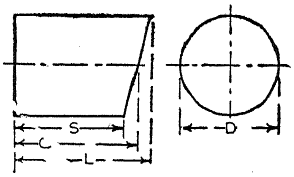
Addit'l. weight.	Addit'l value of K	Addit'l weight.	Addit'l value of K	Addit'l weight.	Addit'l value of K
.001	.0002	.004	.0009	.007	.0015
.002	.0004	.005	.0011	.008	.0017
.003	.0006	.006	.0013	.009	.0019

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



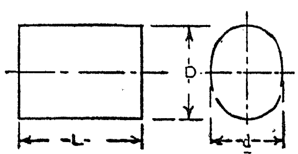
To find the weight of a solid cylinder, multiply the diameter squared by the length, by the constant, k, corresponding to the weight per cubic inch of material used. (See table below.)

Weight $= D^2\ L\ k$



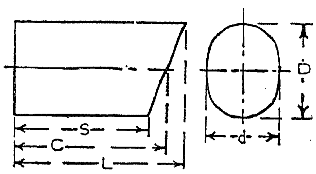
To find the weight of a truncated circular cylinder, multiply the diameter squared by the distance on the center line from the base to the inclined section, by the value of k. C is equal to one-half of the sum of S and L.

Weight $= D^2 C\ k$



To find the weight of an elliptical cylinder, multiply the large diameter by the small diameter, by the length, by the value of k.

Weight $=\ D\ d\ L\ k$



To find the weight of a truncated elliptical cylinder, multiply the small diameter by the large diameter by the distance on the center line from the base to the inclined section, by the value of k. C is equal to one-half the sum of S and L.

Weight $= D\ d\ C\ k$

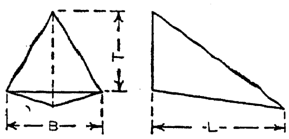
Wt. per cu. in.	k	m	Wt. per cu. in.	k	m	Wt. per cu. in.	k	m	Wt. per cu. in.	k	m
.096	.0754	.0377	.210	.1649	.0825	.330	.2592	.1296	.450	.3534	.1767
.100	.0785	.0394	.220	.1728	.0864	.340	.2670	.1335	.460	.3613	.1806
.110	.0864	.0432	.230	.1806	.0903	.350	.2749	.1374	.470	.3691	.1846
.120	.0942	.0471	.240	.1885	.0942	.360	.2827	.1414	.480	.3770	.1885
.130	.1021	.0511	.250	.1964	.0982	.370	.2906	.1453	.490	.3848	.1924
.140	.1100	.0550	.260	.2042	.1021	.380	.2985	.1492	.500	.3927	.1964
.150	.1178	.0589	.270	.2120	.1060	.390	.3063	.1532	.510	.4006	.2003
.160	.1257	.0628	.280	.2199	.1100	.400	.3142	.1571	.520	.4084	.2042
.170	.1335	.0668	.290	.2278	.1139	.410	.3220	.1610	.530	.4162	.2081
.180	.1414	.0707	.300	.2356	.1178	.420	.3299	.1649	.540	.4241	.2120
.190	.1492	.0746	.310	.2435	.1217	.430	.3377	.1689	.550	.4320	.2160
.200	.1571	.0785	.320	.2513	.1257	.440	.3456	.1728	.560	.4398	.2199

INTERPOLATION TABLE

Ad'l. wt.	Ad'l. k	Ad'l. m	Ad'l. wt.	Ad'l. k	Ad'l. m	Ad'l. wt.	Ad'l. k	Ad'l. m
.001	.0008	.0004	.004	.0031	.0016	.007	.0055	.0027
.002	.0016	.0008	.005	.0039	.0020	.008	.0063	.0031
.003	.0024	.0012	.006	.0047	.0024	.009	.0071	.0035

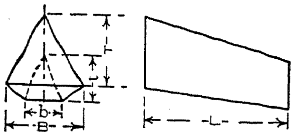
For method of interpolation see page 82.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



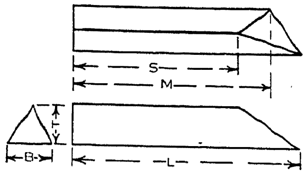
To find the weight of a triangular pyramid, multiply the width of the base by its thickness, by the length, by the constant, k, corresponding to the weight per cubic inch of material used. (See table below.)

$$W = B\ T\ L\ k$$



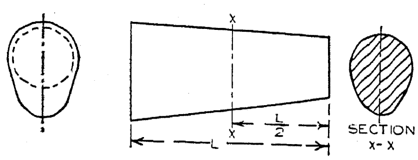
To find the weight of a frustrum of a triangular pyramid, first find the sum of the products of the breadth of the large base by its thickness, the breadth of the small base by its thickness, and the breadth of the large by the thickness of the small base; then multiply this sum by the length by the value of k and the product is the required weight.

$$W = (B\,T + b\,t + B\,t)\,L\,k$$



To find the weight of a truncated triangular casting, multiply the thickness of the base, by its breadth, by the sum of the lateral edges, by the value of k.

$$W = TB\ (L + M + S)k$$



To find the weight of a prismoid or solid generated by a straight line moving over the boundaries of two parallel ends, multiply the sum of the area of the large end, four times the area of the mid-section and the area of the small end by the length, by the value of k.

$$W = (A + 4\,M + E)\,L\,k$$

A = Area large end.
M = Area mid-section, X-X.
E = Area small end.

Wt. per cu. in.	k	Wt. per cu. in.	k	Wt. per cu. in.	k	Wt. per cu. in.	k	Wt. per cu. in.	k	Wt. per cu. in.	k.
.096	.0160	.170	.0283	.250	.0417	.330	.0550	.410	.0683	.490	.0817
.100	.0167	.180	.0300	.260	.0433	.340	.0567	.420	.0700	.500	.0833
.110	.0183	.190	.0317	.270	.0450	.350	.0583	.430	.0717	.510	.0850
.120	.0200	.200	.0333	.280	.0467	.360	.0600	.440	.0733	.520	.0867
.130	.0217	.210	.0350	.290	.0483	.370	.0617	.450	.0750	.530	.0883
.140	.0233	.220	.0367	.300	.0500	.380	.0633	.460	.0767	.540	.0900
.150	.0250	.230	.0383	.310	.0517	.390	.0650	.470	.0783	.550	.0917
.160	.0267	.240	.0400	.320	.0533	.400	.0667	.480	.0800	.560	.0933

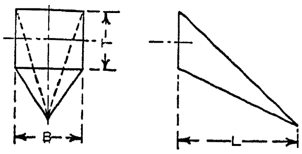
INTERPOLATION TABLE

Additional. Wt.	Additional. k.	Additional. Wt.	Additional. k.	Additional. Wt.	Additional. k.
.001	.0002	.004	.0007	.007	.0012
.002	.0003	.005	.0008	.008	.0013
.003	.0005	.006	.0010	.009	.0015

For method of interpolation see page 82.

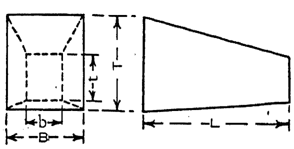
All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



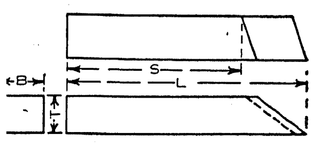
To find the weight of a pyramid with a rectangular base, multiply the thickness of the base by the breadth, by the length, by the constant, *k*, corresponding to the weight per cubic inch of material used. (See table below.)

$$W = T\ B\ L\ K$$



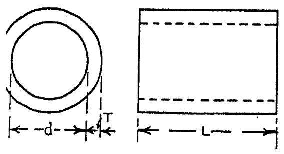
To find the weight of a frustrum of a rectangular pyramid, first find the sum of the products of the breadth of the large base by its thickness, the breadth of the small base by thickness and the breadth of the large by the thickness of the small base; then multiply this sum by the length by the value of *K* and the product is the weight required.

$$W = (BT + bt + Bt)\ L K$$



To find the weight of a truncated rectangular casting, multiply the thickness of the base by its breadth, by the sum of the longest and shortest lateral edges, by one-half of the weight per cubic inch of material used.

$$W = T B\ (S+L)\ \times\ \tfrac{1}{2}\ Wt.\ Per\ cu.\ in.$$



To find the weight of a hollow cylinder, multiply the sum of the inside diameter and the thickness by the thickness, by the length, by the value of *c*, given below

$$W = (d+T)\ T\ L\ C$$

:. per in.	K	C	Wt. per cu. in.	K	C	Wt. per cu. in.	K	C	Wt. per cu. in.	K	C
096	.032	.3016	.210	.0700	.6597	.330	.1100	1.037	.450	.1500	1.414
100	.0333	.3142	.220	.0733	.6912	.340	.1133	1.068	.460	.1533	1.445
110	.0367	.3456	.230	.0767	.7226	.350	.1167	1.100	.470	.1567	1.477
120	.0400	.3770	.240	.0800	.7540	.360	.1200	1.131	.480	.1600	1.508
130	.0433	.4084	.250	.0833	.7854	.370	.1233	1.162	.490	.1633	1.539
140	.0467	.4398	.260	.0867	.8168	.380	.1267	1.194	.500	.1667	1.571
150	.0500	.4712	.270	.0900	.8482	.390	.1300	1.225	.510	.1700	1.602
160	.0533	.5027	.280	.0933	.8796	.400	.1333	1.257	.520	.1733	1.634
170	.0567	.5341	.290	.0967	.9111	.410	.1367	1.288	.530	.1767	1.665
180	.0600	.5655	.300	.1000	.9425	.420	.1400	1.319	.540	.1800	1.696
190	.0633	.5969	.310	.1033	.9739	.430	.1433	1.351	.550	.1833	1.728
200	.0667	.6283	.320	.1067	1.005	.440	.1467	1.382	.560	.1867	1.759

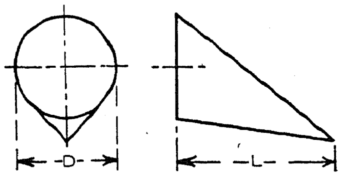
INTERPOLATION TABLE

't. ıd'	K Add'l	C Add'l	Wt. Add'l	K Add'l	C Add'l	Wt. Add'l	K Add'l	C Add'l
001	.0003	.0031	.004	.0013	.0126	.007	.0023	.0220
002	.0007	.0063	.005	.0017	.0157	.008	.0027	.0251
003	.0010	.0094	.006	.0020	.0188	.009	.0030	.0283

For method of interpolation see page 82.

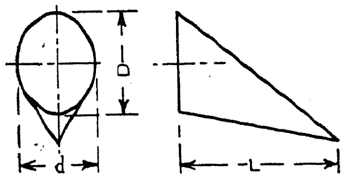
All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



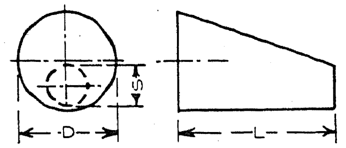
To find the weight of a cone, multiply the diameter squared by the length, by the constant, K, corresponding to the weight per cubic inch. (See table below.)

$$W = D^2LK$$



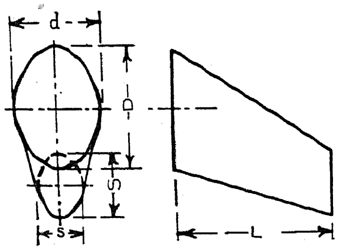
To find the weight of an elliptical cone, multiply the large diameter of the base by the small diameter, by the length, by the value of K.

$$W = DdLK$$



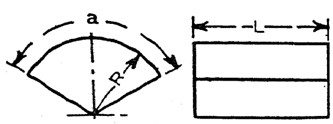
To find the weight of a frustrum of a circular cone, multiply the sum of the diameter of the large base squared, the diameter of the small base squared and the product of the two diameters by the length, by the value of K.

$$W = (D^2 + S^2 + DS)LK$$



To find the weight of a frustrum of an elliptical cone, first find the sum of the products of the large diameter of large base by its small diameter, the large diameter of the small base by its small diameter and the large diameter of the large base by the small diameter of the small base; then the required weight is the product of this sum by the length by the value of K.

$$W = (Dd + Ss + Ds)\,LK$$



To find the weight of a sector of a solid cylinder, multiply the radius squared by the length, by the number of degrees in the angle, by the constant, M, whose value is indicated on page 87.

$$W = R^2LaM$$

Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K
.096	.0251	.170	.0445	.250	.0655	.330	.0864	.410	.1073	.490	.1283
.100	.0261	.180	.0471	.260	.0681	.340	.0890	.420	.1100	.500	.1309
.110	.0288	.190	.0498	.270	.0707	.350	.0916	.430	.1126	.510	.1335
.120	.0314	.200	.0524	.280	.0733	.360	.0943	.440	.1152	.520	.1361
.130	.0340	.210	.0550	.290	.0759	.370	.0969	.450	.1178	.530	.1388
.140	.0367	.220	.0576	.300	.0785	.380	.0995	.460	.1204	.540	.1414
.150	.0393	.230	.0602	.310	.0812	.390	.1021	.470	.1231	.550	.1440
.160	.0419	.240	.0628	.320	.0838	.400	.1047	.480	.1257	.560	.1466

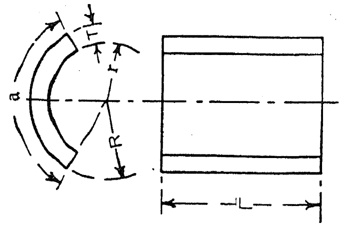
INTERPOLATION TABLE

Ad'l wt.	Ad'l K	Ad'l wt.	Ad'l K	Ad'l wt.	Ad'l K
.001	.0003	.004	.0010	.007	.0018
.002	.0005	.005	.0013	.008	.0021
.003	.0008	.006	.0016	.009	.0024

For method of interpolation see page 82.

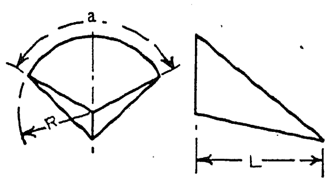
All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



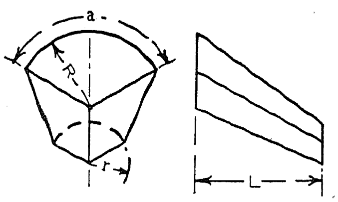
To find the weight of a sector of hollow cylinder, multiply the sum of the inside radius and one-half of the thickness by the thickness, by the length, by the number of degrees in the angle, by the constant, m, corresponding to the weight per cubic inch. (See table below.)

$$W = (r + T/2)\,TLam$$



To find the weight of a sector of a cone, multiply the radius squared by the length by the number of degrees in the angle by the value of C.

$$W = R^2LaC$$



To find the weight of a sector of a frustrum of a cone, multiply the sum of the radius of the large base squared, the radius of the small base squared and the product of the radii by the length, by the number of degrees in the angle, by the value of C.

$$W = (R^2 + r^2 + Rr)\,LaC$$

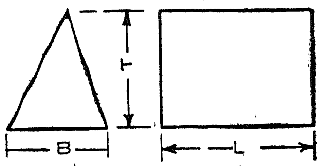
Wt. per cu. in.	M	m	C	Wt. per cu. in.	M	m	C	Wt. per cu. in.	M	m	C
.096	.00084	.00168	.000279	.250	.00218	.00436	.000727	.410	.00358	.00716	.001193
.100	.00087	.00175	.000291	.260	.00227	.00454	.000756	.420	.00367	.00733	.001222
.110	.00096	.00192	.000319	.270	.00236	.00471	.000785	.430	.00375	.00750	.001251
.120	.00105	.00209	.000349	.280	.00244	.00489	.000815	.440	.00384	.00768	.001280
.130	.00113	.00227	.000378	.290	.00253	.00506	.000844	.450	.00393	.00785	.001300
.140	.00122	.00244	.000407	.300	.00262	.00524	.000873	.460	.00401	.00803	.001338
.150	.00131	.00262	.000436	.310	.00271	.00541	.000902	.470	.00410	.00820	.001367
.160	.00140	.00279	.000465	.320	.00279	.00558	.000931	.480	.00419	.00838	.001396
.170	.00148	.00297	.000495	.330	.00288	.00576	.000960	.490	.00428	.00855	.001425
.180	.00157	.00314	.000524	.340	.00297	.00593	.000989	.500	.00436	.00873	.001455
.190	.00166	.00332	.000553	.350	.00305	.00611	.001018	.510	.00445	.00890	.001484
.200	.00175	.00349	.000582	.360	.00314	.00628	.001047	.520	.00454	.00908	.001513
.210	.00183	.00367	.000611	.370	.00323	.00646	.001076	.530	.00463	.00925	.001542
.220	.00192	.00384	.000640	.380	.00332	.00663	.001105	.540	.00471	.00942	.001571
.230	.00201	.00401	.000669	.390	.00340	.00681	.001135	.550	.00480	.00961	.001600
.240	.00209	.00419	.000698	.400	.00349	.00698	.001164	.560	.00489	.00978	.001629

INTERPOLATION TABLE

Ad'l wt.	Ad'l M	Ad'l m	Ad'l C	Ad'l wt.	Ad'l M	Ad'l m	Ad'l C	Ad'l wt.	Ad'l M	Ad'l m	Ad'l C
.001	.00001	.00002	.000003	.004	.00003	.00007	.000012	.007	.00006	.00012	.000020
.002	.00002	.00003	.000006	.005	.00004	.00009	.000015	.008	.00007	.00014	.000023
.003	.00003	.00005	.000009	.006	.00005	.00010	.000017	.009	.00008	.00016	.000026

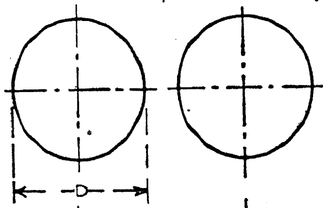
For method of interpolation see page 82.
All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



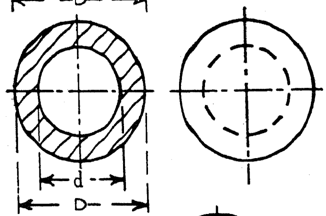
To find the weight of a solid triangular casting, multiply the length by the width, by the thickness, by the constant, K, corresponding to the weight per cubic inch of material used. (See table below.)

$$W=LBTK$$



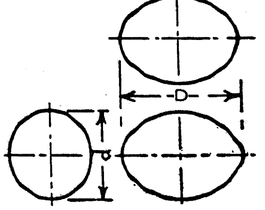
To find the weight of a solid sphere, multiply the diameter cubed by the constant, M, corresponding to the weight per cubic inch.

$$W=D^3M$$



To find the weight of a hollow sphere. multiply the difference between the cubes of the outside and inside diameters by the constant, M, corresponding to the weight per cubic inch.

$$W=(D^3-d^3)M$$



To find the weight of an ellipsoid, multiply the square of the revolving axis by the fixed axis by the constant, M, corresponding to the weight per cubic inch.

$$W=Dd^2\times M$$

Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M
.096	.048	.0503	.210	.105	.1100	.330	.165	.1728	.450	.225	.2356
.100	.050	.0524	.220	.110	.1152	.340	.170	.1780	.460	.230	.2408
.110	.055	.0576	.230	.115	.1204	.350	.175	.1832	.470	.235	.2460
.120	.060	.0628	.240	.120	.1257	.360	.180	.1885	.480	.240	.2513
.130	.065	.0680	.250	.125	.1309	.370	.185	.1937	.490	.245	.2565
.140	.070	.0732	.260	.130	.1361	.380	.190	.1989	.500	.250	.2617
.150	.075	.0785	.270	.135	.1414	.390	.195	.2042	.510	.255	.2670
.160	.080	.0838	.280	.140	.1466	.400	.200	.2094	.520	.260	.2722
.170	.085	.0881	.290	.145	.1518	.410	.205	.2146	.530	.265	.2774
.180	.090	.0943	.300	.150	.1571	.420	.210	.2199	.540	.270	.2827
.190	.095	.0995	.310	.155	.1623	.430	.215	.2251	.550	.275	.2879
.200	.100	.1047	.320	.160	.1675	.440	.220	.2303	.560	.280	.2931

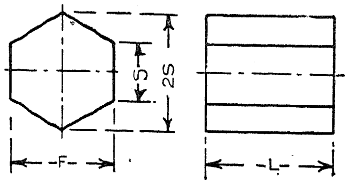
INTERPOLATION TABLE

Ad'l wt.	Ad'l K	Ad'l M	Ad'l wt.	Ad'l K	Ad'l M	Ad'l wt.	Ad'l K	Ad'l M
.001	.0005	.0005	.004	.0020	.0021	.007	.0035	.0037
.002	.0010	.0010	.005	.0025	.0026	.008	.0040	.0042
.003	.0015	.0016	.006	.0030	.0031	.009	.0045	.0049

All dimensions in inches and weights in pounds.

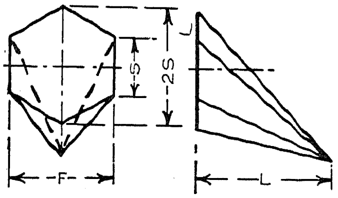
For methods of interpolation see page 82.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



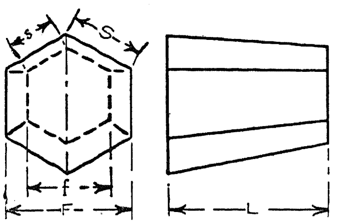
To find the weight of a hexagonal casting, multiply the square of the side by the length, by the constant, *K*, corresponding to the weight per cubic inch, or multiply the square of the distance across the flats by the length by the value of *M*. (See table below.)

$$W=S^2LK \quad or \quad W=F^2LM$$



To find the weight of a pyramid with a hexagonal base, multiply the square of the side by the length, by the value of *M*, or multiply the square of the distance across flats by the length, by the value of *C*.

$$W=S^2LM \quad or \quad W=F^2LC$$



To find the weight of a frustrum of a hexagonal pyramid, multiply the sum of the side of the large base squared, the side of small base squared and the product of the two sides by the length, by *M*, or multiply the sum of the distance across the flats of the large base squared, the distance across the flats of the small base squared and the product of the two sides by the length of *C*.

$$W=(S^2+s^2+Ss)LM \quad or \quad W=(F^2+f^2+Ff)LC$$

Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C
.096	.2494	.0831	.0277	.250	.6495	.2165	.0722	.410	1.0652	.3551	.1184
.100	.2598	.0866	.0289	.260	.6755	.2252	.0751	.420	1.0912	.3637	.1212
.110	.2858	.0953	.0318	.270	.7015	.2338	.0779	.430	1.1172	.3724	.1241
.120	.3118	.1039	.0346	.280	.7275	.2425	.0808	.440	1 1432	.3811	.1270
.130	.3378	.1126	.0375	.290	.7534	.2512	.0837	.450	1.1691	.3897	.1299
.140	.3637	.1212	.0404	.300	.7794	.2598	.0866	.460	1.1951	.3984	.1328
.150	.3897	.1299	.0433	.310	.8054	.2685	.0895	.470	1.2211	.4070	.1357
.160	.4157	.1386	.0462	.320	.8314	.2771	.0924	.480	1.2471	.4157	.1386
.170	.4417	.1472	.0491	.330	.8574	.2858	.0953	.490	1.2731	.4244	.1415
.180	.4677	.1550	.0520	.340	.8833	.2944	.0981	.500	1.2990	.4330	.1443
.190	.4936	.1645	.0548	.350	.9093	.3031	.1010	.510	1.3250	.4417	.1472
.200	.5196	.1732	.0577	.360	.9353	.3118	.1039	.520	1.3510	.4503	.1501
.210	.5456	.1819	.0606	.370	.9613	.3204	.1068	.530	1.3770	.4590	.1530
.220	.5716	.1905	.0635	.380	.9873	.3291	.1097	.540	1.4030	.4677	.1559
.230	.5976	.1992	.0664	.390	1.0133	.3378	.1126	.550	1.4289	.4763	.1588
.240	.6235	.2079	.0693	.400	1.0392	.3464	.1155	.560	1.4549	.4850	.1617

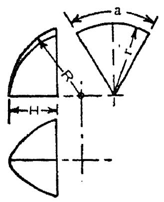
INTERPOLATION TABLE

Ad'l wt.	Ad'l K	Ad'l M	Ad'l C	Ad'l wt.	Ad'l K	Ad'l M	Ad'l C	Ad'l wt.	Ad'l K	Ad'l M	Ad'l C
.001	.0026	.0009	.0003	.004	.0104	.0035	.0012	.007	.0181	.0060	.0020
.002	.0052	.0017	.0006	.005	.0130	.0043	.0014	.008	.0207	.0069	.0023
.003	.0078	.0026	.0009	.006	.0155	.0052	.0017	.009	.0233	.0078	.0026

For method of interpolation see page 82.
All dimensions in inches and weights in pounds

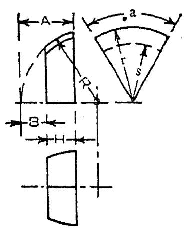
FORMULAS FOR FINDING WEIGHTS OF CASTINGS

(Continued)



To find the weight of a sector of a spherical segment of one base, multiply the difference between the radius of the sphere and one-third of the height by the height squared, by the number of degrees in the angle by K, or to the radius of the base squared multiplied by the height by the number of degrees in the angle by M, add the height cubed multiplied by the number of degrees by C.

$$W = \left(R - \frac{H}{3}\right) H^2 aK \text{ or } W = r^2 HaM + H^3 aC$$



To find the weight of a sector of a spherical segment of two bases; from the difference between the squares of the distances from the bases to the pole multiplied by the radius of the sphere by the number of degrees in the angle by K, subtract the difference between the cubes of the distances from the bases to the pole multiplied by the number of degrees by C, obtained from the table on page 97, or to the sum of the squares of the radii of the bases multiplied by the height by the number of degrees in the angle by M, add the height cubed multiplied by the number of degrees in the angle by C.

$$W = (A^2 - B^2) RaK - (A^3 - B^3) aC$$

or $W = (r^2 + s^2) HaM + H^3 aC$

Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C
.096	.00084	.000419	.000140	.250	.00218	.001092	.000363	.410	.00358	.001789	.000596
.100	.00087	.000436	.000145	.260	.00227	.001135	.000378	.420	.00367	.001833	.000611
.110	.00096	.000480	.000160	.270	.00236	.001179	.000393	.430	.00375	.001876	.000625
.120	.00105	.000524	.000174	.280	.00244	.001223	.000407	.440	.00384	.001920	.000640
.130	.00113	.000567	.000189	.290	.00253	.001266	.000421	.450	.00393	.001964	.000654
.140	.00122	.000611	.000203	.300	.00262	.001309	.000436	.460	.00401	.002008	.000669
.150	.00131	.000655	.000218	.310	.00271	.001358	.000450	.470	.00410	.002052	.000684
.160	.00140	.000698	.000238	.320	.00279	.001397	.000465	.480	.00419	.002095	.000698
.170	.00148	.000742	.000247	.330	.00288	.001440	.000480	.490	.00428	.002139	.000712
.180	.00157	.000786	.000261	.340	.00297	.001483	.000495	.500	.00436	.002182	.000727
.190	.00166	.000830	.000276	.350	.00305	.001527	.000509	.510	.00445	.002226	.000741
.200	.00175	.000873	.000291	.360	.00314	.001571	.000524	.520	.00454	.002270	.000756
.210	.00183	.000917	.000305	.370	.00323	.001615	.000538	.530	.00463	.002313	.000770
.220	.00192	.000961	.000319	.380	.00332	.001659	.000558	.540	.00471	.002356	.000785
.230	.00201	.001004	.000334	.390	.00340	.001702	.000567	.550	.00480	.002400	.000800
.240	.00209	.001048	.000349	.400	.00349	.001745	.000582	.560	.00489	.002443	.000815

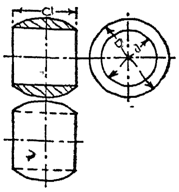
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. M	Add'l. C	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. C	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. C
.001	.00001	.000004	.000001	.004	.00003	.000017	.000006	.007	.00006	000031	.000010
.002	.00002	.000009	.000003	.005	.00004	.000022	.000007	.008	.00007	.000035	.000012
.003	.00003	.000013	.000004	.006	.00005	.000026	.000009	.009	.00008	.000039	.000013

For method of interpolation see page 82.

All Dimensions in Inches and Weights in Pounds

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)

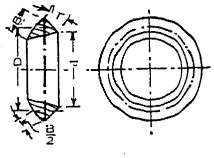


To find the weight of a ring made by cutting a cylindrical hole through the center of a sphere, multiply the chord cubed by the value of K corresponding to the weight per cubic inch of material used. (See table below).

$$W = C^3 K$$

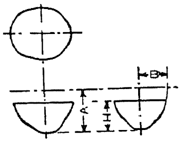
The chord is equal to the square root of the result obtained by subtracting the square of the diameter of the hole from the square of the diameter of the sphere.

$$C = \sqrt{D^2 - d^2}$$



To find the weight of a ring of triangular cross-section, multiply the base of the triangle by its altitude, by the sum of twice the diameter of the circle described, by the center of the base and the diameter described by the vertex of the triangle by the value of K.

$$W = BT(2D + d)K$$



To find the weight of a segment of an ellipsoid, when the base is parallel to the revolving axis, multiply the difference between three times the fixed semi-axis and the height of the segment by the square of the height, by the square of the revolving semi-axis, by the value of M and divide by the square of the fixed semi-axis.

$$W = \frac{(3A - H)H^2B^2M}{A^2}$$

Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M
.096	.0503	.1005	.210	.1100	.2199	.330	.1723	.3456	.450	.2356	.4713
.100	.0524	.1047	.220	.1152	.2304	.340	.1780	.3561	.460	.2408	.4817
.110	.0576	.1152	.230	.1204	.2408	.350	.1832	.3666	.470	.2460	.4922
.120	.0628	.1257	.240	.1257	.2513	.360	.1885	.3770	.480	.2513	.5026
.130	.0680	.1361	.250	.1309	.2618	.370	.1937	.3875	.490	.2565	.5131
.140	.0732	.1466	.260	.1361	.2722	.380	.1989	.3980	.500	.2617	.5236
.150	.0785	.1571	.270	.1414	.2827	.390	.2042	.4084	.510	.2670	.5341
.160	.0838	.1675	.280	.1466	.2932	.400	.2094	.4189	.520	.2722	.5446
.170	.0881	.1780	.290	.1518	.3037	.410	.2146	.4294	.530	.2774	.5550
.180	.0943	.1885	.300	.1571	.3142	.420	.2199	.4399	.540	.2827	.5654
.190	.0995	.1990	.310	.1623	.3247	.430	.2251	.4504	.550	.2879	.5759
.200	.1047	.2094	.320	.1675	.3352	.440	.2303	.4609	.560	.2931	.5864

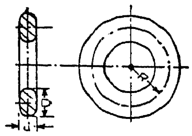
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. M	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. Wt.	Add'l. K	Add'l. M
.001	.0005	.0010	.004	.0021	.0042	.007	.0037	.0073
.002	.0010	.0021	.005	.0026	.0052	.008	.0042	.0084
.003	.0016	.0031	.006	.0031	.0063	.009	.0049	.0094

For method of interpolation see page 82.

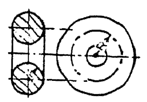
All Dimensions in Inches and Weights in Pounds

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



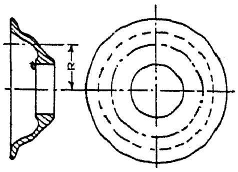
To find the weight of a ring of elliptical cross-section, multiply the radius of the circle passing through the center of the cross-section by the large diameter of the ellipse, by the small diameter, by the value of the constant, K, corresponding to the weight per cubic inch of material used.

$$W=RDdK$$



To find the weight of a ring of circular cross-section, multiply the radius of the cross-section squared by the radius of the circle passing through the center of the cross-section, by the value of M.

$$W=r^2RM$$



To find the weight of a solid generated by revolving a plane area about an axis, multiply the area by the distance from the center of gravity of cross-section to the axis by the value of N.

$$W=ARN$$

Wt. per cu. in.	K	M	N	Wt. per cu. in.	K	M	N	Wt. per cu. in.	K	M	N
.096	.474	1.895	.603	.250	1.234	4.935	1.571	.410	2.023	8.093	2.576
.100	.494	1.974	.628	.260	1.283	5.132	1.634	.420	2.073	8.291	2.639
.110	.543	2.171	.691	.270	1.332	5.330	1.696	.430	2.122	8.488	2.702
.120	.592	2.369	.754	.280	1.382	5.527	1.759	.440	2.171	8.685	2.765
.130	.642	2.566	.817	.290	1.431	5.724	1.822	.450	2.221	8.883	2.827
.140	.691	2.764	.880	.300	1.481	5.922	1.885	.460	2.270	9.080	2.890
.150	.740	2.961	.942	.310	1.530	6.119	1.948	.470	2.319	9.277	2.953
.160	.790	3.158	1.005	.320	1.579	6.317	2.011	.480	2.369	9.475	3.016
.170	.839	3.356	1.068	.330	1.629	6.514	2.073	.490	2.418	9.672	3.079
.180	.888	3.553	1.181	.340	1.678	6.711	2.136	.500	2.468	9.870	3.142
.190	.938	3.751	1.194	.350	1.727	6.909	2.199	.510	2.517	10.067	3.204
.200	.987	3.948	1.257	.360	1.777	7.106	2.262	.520	2.566	10.264	3.267
.210	1.036	4.145	1.319	.370	1.826	7.304	2.325	.530	2.616	10.462	3.330
.220	1.086	4.343	1.382	.380	1.875	7.501	2.388	.540	2.665	10.659	3.393
.230	1.135	4.540	1.445	.390	1.925	7.698	2.450	.550	2.714	10.857	3.456
.240	1.184	4.737	1.508	.400	1.974	7.896	2.513	.560	2.764	11.054	3.519

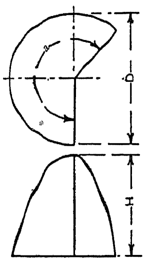
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. M	Add'l. N	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. N	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. N
.001	.005	.020	.007	.004	.020	.079	.025	.007	.035	.138	.044
.002	.010	.039	.013	.005	.025	.099	.031	.008	.039	.158	.050
.003	.015	.059	.019	.006	.030	.113	.033	.009	.044	.178	.057

For method of interpolation see page 82.
For finding Center of Gravity, see page 23.
For finding Area of Irregular Figures, see page 22.

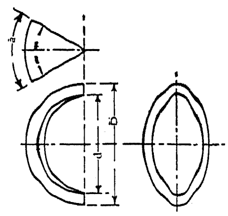
All Dimensions in Inches and Weights in Pounds

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



To find the weight of a sector of a paraboloid, multiply the diameter of the base squared by the height, by the number of degrees in the angle by the value of K (see table below) corresponding to the weight per cubic inch of material used.

$$W=D^2HaK$$



To find the weight of a spherical wedge, multiply the diameter of the sphere cubed by the number of degrees in the angle by the value of M.

$$W=D^3aM$$

Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M
.096	.000105	.000140	.210	.000229	.000305	.330	.000360	.000480	.450	.000491	.000654
.100	.000109	.000145	.220	.000240	.000319	.340	.000371	.000495	.460	.000501	.000669
.110	.000120	.000160	.230	.000251	.000334	.350	.000382	.000509	.470	.000512	.000684
.120	.000131	.000174	.240	.000262	.000349	.360	.000393	.000524	.480	.000523	.000698
.130	.000142	.000189	.250	.000273	.000363	.370	.000403	.000538	.490	.000534	.000712
.140	.000153	.000203	.260	.000283	.000378	.380	.000414	.000553	.500	.000545	.000727
.150	.000164	.000218	.270	.000294	.000393	.390	.000425	.000567	.510	.000556	.000741
.160	.000174	.000233	.280	.000305	.000407	.400	.000436	.000582	.520	.000567	.000756
.170	.000185	.000247	.290	.000316	.000421	.410	.000447	.000596	.530	.000578	.000770
.180	.000196	.000261	.300	.000327	.000436	.420	.000458	.000611	.540	.000589	.000785
.190	.000207	.000276	.310	.000338	.000450	.430	.000469	.000625	.550	.000600	.000800
.200	.000218	.000291	.320	.000349	.000465	.440	.000480	.000640	.560	.000611	.000815

INTERPOLATION TABLE

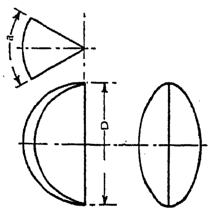
Add'l. Wt.	Add'l. K	Add'l. M	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. Wt.	Add'l. K	Add'l. M
.001	.000001	.000001	.004	.000004	.000006	.007	.000008	.000010
.002	.000002	.000003	.005	.000005	.000007	.008	.000009	.000012
.003	.000003	.000004	.006	.000007	.000009	.009	.000010	.000013

For method of interpolation see page 82.

All dimensions in inches and weights in pounds

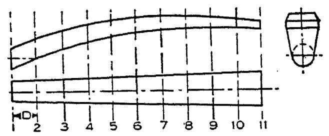
FORMULAS FOR FINDING WEIGHTS OF CASTINGS

(Continued)



To find the weight of a hollow spherical wedge, multiply the difference between the outside diameter cubed and the inside diameter cubed by the number of degrees in the angle, by the value of M (see table on page 93) corresponding to the weight per cubic inch of material used.

$$W=(D^3-d^3)aM$$



To find the weight of an irregular casting, which cannot be divided into elementary solids, use the following method based on Simpson's rule:

Divide the length of the casting into an even number of parts of equal length D (the greater the number of divisions, the greater will be the accuracy in the final result) by parallel planes. Add the areas of the two ends and designate the sum A. Add the areas of the cross-sections made by the even cutting planes, i. e. 2, 4, 6, etc., and designate this sum by B. Then add the area made by the odd cutting planes, except the ends, calling this sum C.

The weight of the casting is equal to the sum of A, *four* times B and *two* times C multiplied by D, by the value of K.

$$W=(A+4B+2C)DK$$

Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K	Wt. per cu. in.	K
.096	.0320	.170	.0567	.250	.0833	.330	.1100	.410	.1367	.490	.1633
.100	.0333	.180	.0600	.260	.0867	.340	.1133	.420	.1400	.500	.1667
.110	.0367	.190	.0633	.270	.0900	.350	.1167	.430	.1433	.510	.1700
.120	.0400	.200	.0667	.280	.0933	.360	.1200	.440	.1467	.520	.1733
.130	.0433	.210	.0700	.290	.0967	.370	.1233	.450	.1500	.530	.1767
.140	.0467	.220	.0733	.300	.1000	.380	.1267	.460	.1533	.540	.1800
.150	.0500	.230	.0767	.310	.1033	.390	.1300	.470	.1567	.550	.1833
.160	.0533	.240	.0800	.320	.1067	.400	.1333	.480	.1600	.560	.1867

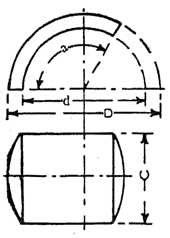
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. Wt.	Add'l. K	Add'l. Wt.	Add'l. K
.001	.0003	.004	.0013	.007	.0023
.002	.0007	.005	.0017	.008	.0027
.003	.0010	.006	.0020	.009	.0030

For method of Interpolation see page 82.

All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)

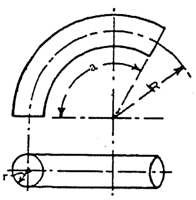


To find the weight of a sector of a ring made by cutting a cylindrical hole through the center of a sphere, multiply the chord cubed by the number of degrees in the angle by the value of K corresponding to the weight per cubic inch of material used. (See table below.)

$$W=C^3aK$$

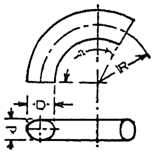
The chord is equal to the square root of the result obtained by subtracting the square of the diameter of the hole from the square of the diameter of the sphere.

$$C=\sqrt{D^2-d^2}$$



To find the weight of a sector of a ring of circular cross-section, multiply the radius of the cross-section squared by the radius of the circle passing through the center of the cross-section by the number of degrees in the angle by the value of M.

$$W=r^2RaM$$



To find the weight of a segment of a ring of elliptical cross-section, multiply the radius of the circle passing through the center of the cross-section by the large diameter of the ellipse, by the small diameter, by the number of degrees in the angle, by the value of K. (See page 96.)

$$W=RDdaK$$

Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M	Wt. per cu. in.	K	M
.096	.000140	.00526	.210	.000305	.01151	.330	.000480	.01809	.450	.000654	.02467
.100	.000145	.00548	.220	.000319	.01206	.340	.000495	.01864	.460	.000669	.02522
.110	.000160	.00603	.230	.000334	.01261	.350	.000509	.01919	.470	.000684	.02577
.120	.000174	.00658	.240	.000349	.01316	.360	.000524	.01974	.480	.000698	.02632
.130	.000189	.00713	.250	.000363	.01371	.370	.000538	.02029	.490	.000712	.02687
.140	.000203	.00768	.260	.000378	.01426	.380	.000553	.02084	.500	.000727	.02742
.150	.000218	.00822	.270	.000393	.01480	.390	.000567	.02138	.510	.000741	.02796
.160	.000233	.00877	.280	.000407	.01535	.400	.000582	.02193	.520	.000756	.02851
.170	.000247	.00932	.290	.000421	.01590	.410	.000596	.02248	.530	.000770	.02906
.180	.000261	.00987	.300	.000436	.01645	.420	.000611	.02303	.540	.000785	.02961
.190	.000276	.01042	.310	.000450	.01700	.430	.000625	.02358	.550	.000800	.03016
.200	.000291	.01097	.320	.000465	.01755	.440	.000640	.02413	.560	.000815	.03071

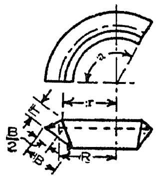
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. M	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. Wt.	Add'l. K	Add'l. M
.001	.000001	.00005	.004	.000006	.00022	.007	.000010	.00038
.002	.000003	.00011	.005	.000007	.00027	.008	.000012	.00044
.003	.000004	.00016	.006	.000009	.00033	.009	.000013	.00049

For method of Interpolation see page 82.

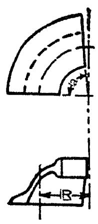
All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



To find the weight of a segment of a ring of triangular cross-section multiply the base of the triangle by the altitude, by the sum of twice the radius of the circle described, by the center of the base and the radius of the circle described, by the vertex of the triangle, by the number of degrees in the angle, by the value of M corresponding to the weight per cubic inch of material used.

$$W = BTaM(2R+r)$$



To find the weight of a segment of a solid generated by revolving a plane area about an axis, multiply the area by the distance from the center of gravity of cross-section to the axis, by the number of degrees in the angle by the value of N.

$$W = ARaN$$

For finding area of irregular figures, see page 22.
For finding center of gravity, see page 23.

Wt. per cu. in.	K	M	N	Wt. per cu. in.	K	M	N	Wt. per cu. in.	K	M	N
.096	.00132	.000279	.00168	.250	.00343	.000727	.00436	.410	.00561	.001193	.00715
.100	.00137	.000291	.00175	.260	.00356	.000756	.00454	.420	.00575	.001222	.00733
.110	.00150	.000319	.00192	.270	.00370	.000785	.00471	.430	.00589	.001251	.00750
.120	.00164	.000349	.00210	.280	.00384	.000815	.00489	.440	.00603	.001280	.00768
.130	.00178	.000378	.00227	.290	.00397	.000844	.00506	.450	.00617	.001309	.00785
.140	.00192	.000407	.00244	.300	.00411	.000873	.00524	.460	.00630	.001338	.00803
.150	.00206	.000436	.00262	.310	.00425	.000902	.00541	.470	.00644	.001368	.00820
.160	.00220	.000465	.00279	.320	.00438	.000931	.00558	.480	.00658	.001397	.00833
.170	.00233	.000495	.00297	.330	.00452	.000960	.00576	.490	.00672	.001426	.00855
.180	.00246	.000524	.00314	.340	.00466	.000989	.00593	.500	.00685	.001455	.00878
.190	.00260	.000553	.00331	.350	.00480	.001018	.00611	.510	.00699	.001484	.00890
.200	.00274	.000582	.00349	.360	.00493	.001047	.00628	.520	.00713	.001513	.00903
.210	.00288	.000611	.00366	.370	.00507	.001076	.00645	.530	.00727	.001542	.00925
.220	.00301	.000640	.00384	.380	.00521	.001106	.00663	.540	.00740	.001571	.00942
.230	.00315	.000669	.00401	.390	.00534	.001135	.00680	.550	.00754	.001600	.00959
.240	.00329	.000698	.00419	.400	.00548	.001164	.00693	.560	.00768	.001629	.00977

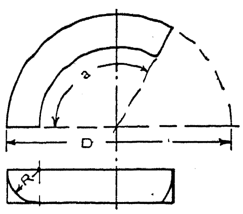
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. M	Add'l. N	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. N	Add'l. Wt.	Add'l. K	Add'l. M	Add'l N
.001	.00001	.000003	.00002	.004	.00005	.000012	.00007	.007	.00009	.000020	.00012
.002	.00003	.000006	.00003	.005	.00007	.000015	.00009	.008	.00011	.000023	.00014
.003	.00004	.000009	.00005	.006	.00008	.000017	.00010	.009	.00012	.000026	.00016

For method of Interpolation, see page 82.

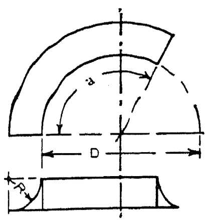
All dimensions in inches and weights in pounds.

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



To find the weight of a sector of an inside circular fillet, multiply the difference between the diameter of the cylinder made by the side of the fillet and the product of the radius and 0.446, by the radius squared, by the number of degrees in the angle, by the value of K corresponding to the weight per cubic inch of material used (see table below) or, from the diameter of the cylinder made by the side of the fillet, multiplied by the radius squared, by the number of degrees in the angle, by K, subtract the radius cubed by the number of degrees by M.

$$W=(D-0.446R)R^2aK \quad \text{or} \quad W=DR^2aK-R^3aM$$



To find the weight of a sector of an outside circular fillet, multiply the sum of the diameter made by the side of the fillet and the product of the radius and 0.446 by the radius squared by the number of degrees in the angle by K, or to the diameter of the cylinder made by the side of the fillet multiplied by the radius squared by the number of degrees by K, add the radius cubed multiplied by the number of degrees by M.

$$W=(D+0.446R)R^2aK \quad \text{or} \quad W=DR^2aK+R^3aM$$

Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C
.096	.000180	.000080	.000279	.250	.000468	.000209	.000727	.410	.000763	.000342	.001193
.100	.000187	.000084	.000291	.260	.000485	.000217	.000756	.420	.000787	.000351	.001222
.110	.000206	.000092	.000319	.270	.000505	.000226	.000785	.430	.000805	.000359	.001251
.120	.000224	.000101	.000349	.280	.000524	.000234	.000815	.440	.000824	.000367	.001280
.130	.000243	.000109	.000378	.290	.000543	.000242	.000844	.450	.000843	.000376	.001309
.140	.000262	.000117	.000407	.300	.000562	.000251	.000873	.460	.000861	.000384	.001338
.150	.000281	.000126	.000436	.310	.000581	.000259	.000902	.470	.000880	.000392	.001368
.160	.000299	.000134	.000465	.320	.000600	.000267	.000931	.480	.000898	.000401	.001397
.170	.000313	.000142	.000496	.330	.000618	.000276	.000960	.490	.000917	.000409	.001426
.180	.000337	.000151	.000524	.340	.000636	.000284	.000989	.500	.000936	.000418	.001455
.190	.000356	.000159	.000553	.350	.000655	.000293	.001018	.510	.000955	.000426	.001484
.200	.000375	.000167	.000582	.360	.000673	.000301	.001047	.520	.000973	.000435	.001513
.210	.000394	.000176	.000611	.370	.000692	.000309	.001076	.530	.000992	.000443	.001542
.220	.000413	.000184	.000640	.380	.000711	.000318	.001106	.540	.001010	.000451	.001571
.230	.000431	.000192	.000669	.390	.000730	.000326	.001135	.550	.001029	.000459	.001600
.240	.000450	.000201	.000698	.400	.000749	.000334	.001164	.560	.001048	.000468	.001629

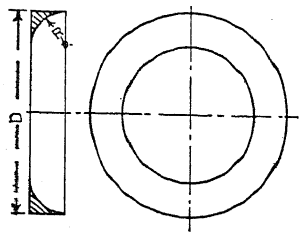
INTERPOLATION TABLE

Add'l. Wt.	Add'l. K	Add'l. M	Add'l. C	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. C	Add'l. Wt.	Add'l. K	Add'l. M	Add'l. C
.001	.000002	.000001	.000003	.004	.000007	.000003	.000012	.007	.000013	.000006	.000020
.002	.000004	.000002	.000006	.005	.000009	.000004	.000015	.008	.000015	.000007	.000023
.003	.000006	.000003	.000009	.006	.000011	.000005	.000017	.009	.000017	.000008	.000026

For method of interpolation see page 82.

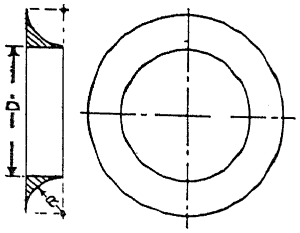
All dimensions in inches and weights in pounds

FORMULAS FOR FINDING WEIGHTS OF CASTINGS
(Continued)



To find the weight of an inside circular fillet, multiply the difference between the diameter of the cylinder made by the side of the fillet and the product of the radius and 0.446, by the radius squared, by the constant *K*, corresponding to weight per cubic inch, or from the diameter of the cylinder made by the side of the fillet multiplied by the radius squared, by the constant *K*, subtract the radius cubed multiplied by constant *M*. (See table below.)

$$W=(D-0.446R)R^2K \quad \text{or} \quad W=DR^2K-R^3M$$



To find the weight of an outside circular fillet, multiply the sum of the diameter made, by the side of the fillet and the product of the radius and 0.446, by the radius squared by the value of *K*, or

To the diameter of the cylinder made by the side of the fillet, multiplied by the radius squared, by the constant *K*, add the radius cubed multiplied by the value of *M*.

$$W=(D+0.446R)R^2K \quad \text{or} \quad W=DR^2K+R^3M$$

Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C	Wt. per cu. in.	K	M	C
.096	.0647	.0289	.0105	.250	.1686	.0752	.2617	.410	.2764	.1233	.4293
.100	.0674	.0301	.1047	.260	.1753	.0782	.2722	.420	.2832	.1263	.4398
.110	.0742	.0331	.1152	.270	.1820	.0812	.2827	.430	.2899	.1293	.4503
.120	.0809	.0361	.1257	.280	.1888	.0842	.2931	.440	.2966	.1323	.4607
.130	.0876	.0391	.1361	.290	.1955	.0872	.3036	.450	.3034	.1353	.4712
.140	.0944	.0421	.1466	.300	.2023	.0902	.3142	.460	.3101	.1383	.4817
.150	.1011	.0451	.1571	.310	.2090	.0932	.3246	.470	.3169	.1413	.4922
.160	.1079	.0481	.1675	.320	.2157	.0962	.3351	.480	.3236	.1443	.5027
.170	.1146	.0511	.1780	.330	.2225	.0992	.3456	.490	.3304	.1473	.5131
.180	.1214	.0541	.1885	.340	.2292	.1022	.3560	.500	.3371	.1503	.5236
.190	.1281	.0571	.1989	.350	.2360	.1052	.3665	.510	.3438	.1533	.5341
.200	.1348	.0601	.2094	.360	.2427	.1083	.3770	.520	.3506	.1563	.5446
.210	.1416	.0631	.2199	.370	.2495	.1113	.3874	.530	.3573	.1594	.5550
.220	.1483	.0662	.2303	.380	.2562	.1143	.3879	.540	.3641	.1624	.5655
.230	.1551	.0692	.2408	.390	.2629	.1173	.4084	.550	.3708	.1654	.5760
.240	.1618	.0722	.2513	.400	.2697	.1203	.4189	.560	.3776	.1684	.5864

INTERPOLATION TABLE

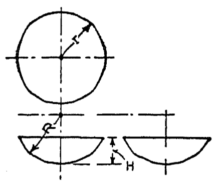
Add'l. wt.	Add'l. K	Add'l. M	Add'l. C	Add'l wt.	Add'l K	Add'l M	Add'l C	Add'l wt.	Add'l K	Add'l M	Add'l C
.001	.0007	.0003	.0010	.004	.0027	.0012	.0042	.007	.0047	.0021	.0073
.002	.0013	.0006	.0021	.005	.0034	.0015	.0052	.008	.0054	.0024	.0084
.003	.0020	.0009	.0031	.006	.0040	.0018	.0063	.009	.0061	.0027	.0094

For method of interpolation, see page 82.

All dimensions in inches and weights in pounds

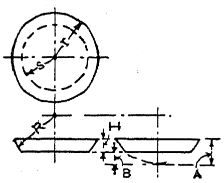
FORMULAS FOR FINDING WEIGHTS OF CASTINGS

(Concluded)



To find the weight of a spherical segment of one base, multiply the square of the height by the difference between the radius of the sphere and one-third of the height by the value of K corresponding to the weight per cubic inch of material used, or, to the radius of the base squared multiplied by the height, by the value of m add the height cubed multiplied by the value of c.

$$W = \left(R - \frac{H}{3}\right) H^2 k \quad \text{or} \quad W = r^2 H m + H^3 c$$



To find the weight of a spherical segment of two bases, from the radius of the sphere multiplied by the difference between the squares of the distances from the bases to the pole, by the constant K, subtract the difference between the cubes of the distances from the bases to the pole multiplied by the constant C, obtained from the table on page 98, or to the sum of the squares of the radii of the bases multiplied by the height by the value of m, add the height cubed multiplied by the value of c.

$$W = (A^2 - B^2) RK - (A^3 - B^3) C \quad \text{or}$$
$$W = (r^2 + s^2) H m + H^3 c$$

Wt. per cu. in.	K	m	c	Wt. per cu. in.	K	m	c	Wt. per cu. in.	K	m	c
.096	.3016	.1508	.0503	.250	.7854	.3927	.1309	.410	1.288	.6440	.2146
.100	.3142	.1571	.0524	.260	.8168	.4084	.1361	.420	1.319	.6528	.2199
.110	.3456	.1728	.0526	.270	.8482	.4241	.1414	.430	1.351	.6755	.2251
.120	.3770	.1885	.0628	.280	.8796	.4308	.1466	.440	1.382	.6912	.2303
.130	.4084	.2042	.0680	.290	.9111	.4556	.1518	.450	1.414	.7060	.2356
.140	.4398	.2199	.0732	.300	.9425	.4712	.1571	.460	1.445	.7226	.2408
.150	.4712	.2356	.0785	.310	.9739	.4870	.1623	.470	1.477	.7388	.2460
.160	.5027	.2514	.0838	.320	1.005	.5027	.1675	.480	1.508	.7540	.2513
.170	.5341	.2676	.0881	.330	1.037	.5184	.1728	.490	1.539	.7697	.2565
.180	.5655	.2828	.0943	.340	1.068	.5341	.1780	.500	1.571	.7854	.2617
.190	.5969	.2985	.0995	.350	1.100	.5498	.1832	.510	1.602	.8009	.2670
.200	.6283	.3142	.1047	.360	1.131	.5655	.1885	.520	1.634	.8168	.2722
.210	.6598	.3299	.1100	.370	1.162	.5811	.1937	.530	1.665	.8325	.2774
.220	.6912	.3456	.1152	.380	1.194	.5969	.1989	.540	1.696	.8482	.2827
.230	.7226	.3613	.1204	.390	1.225	.6126	.2042	.550	1.728	.8639	.2879
.240	.7540	.3770	.1257	.400	1.257	.6283	.2094	.560	1.759	.8796	.2931

INTERPOLATION TABLE

Add'l wt.	Add'l K	Add'l m	Add'l c	Add'l wt.	Add'l K	Add'l m	Add'l c	Add' wt.	Add'l K	Add'l m	Add'l c
.001	.0031	.0016	.0005	.004	.0126	.0063	.0021	.007	.0220	.0110	.0037
.002	.0063	.0031	.0010	.005	.0157	.0079	.0026	.008	.0251	.0126	.0042
.003	.0094	.0047	.0015	.006	.0188	.0094	.0031	.009	.0283	.0142	.0049

For method of interpolation, see page 82.

All dimensions in inches and weights in pounds.

COMPUTING WEIGHTS OF THIN CASTINGS

Caps and Covers

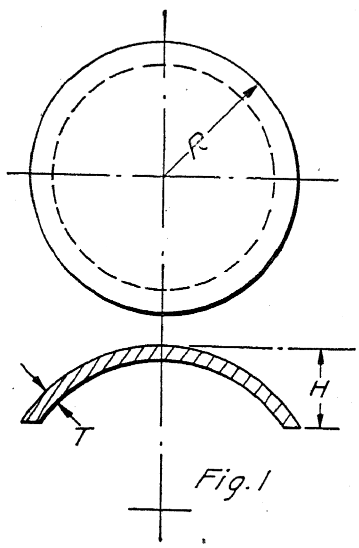


Fig. 1

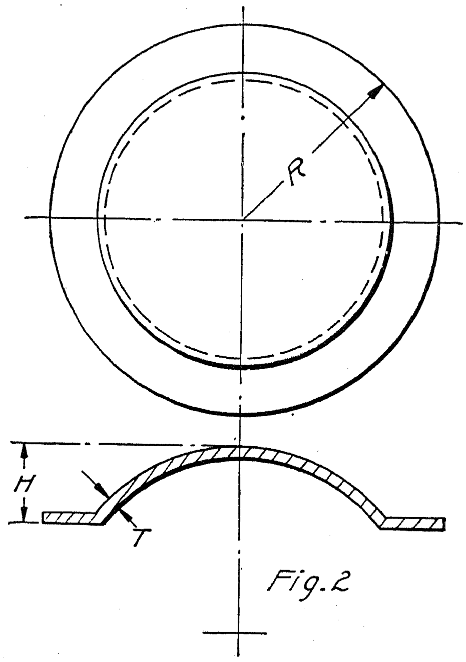


Fig. 2

To find the weight of a thin cap or cover, such as shown in Figs. 1 or 2, multiply the sum of the square of the outside radius and the square of the height by the thickness times the constant *K*, obtained from the table below.

$$W=(R^2+H^2)TK$$

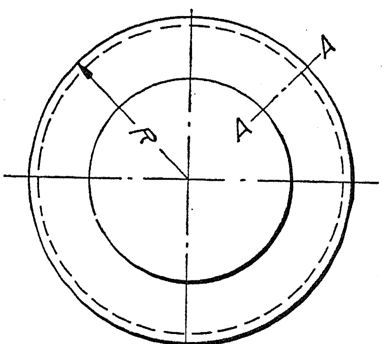
Values of K for Various Metals

Cast Iron	Steel	Aluminum	Copper	Zinc	Gun Metal	Yellow Brass
.818	.890	.303	1.00	.793	.990	.950

If *R* is not greater than 10 inches, the weight can be found by use of tables on pages 113 and 114, as follows:

Add to the weight per inch of a rod whose diameter is 2*R*, the weight per inch of a rod whose diameter is 2*H*. Then the weight required is this sum multiplied by *T*.

COMPUTING WEIGHTS OF THIN CASTINGS
(Concluded)



Plan View for Fig. 1 or Fig. 2

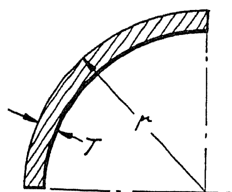


Fig. 1
Enlarged Section A-A

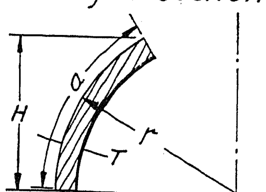


Fig. 2
Enlarged Section A-A

In Fig. 2, *a* is the length of the arc in inches. All other dimensions are in inches and weights in pounds.

Caps and Covers

To find the weight of ring made by revolving a thin quadrant of a circle about an axis, as shown in Fig. 1, multiply the difference between the outside radius and one-third of the radius of the quadrant by the radius of the quadrant times the thickness, times the constant *C* obtained from the table below.

$$W=(R-1/3r)rTC$$

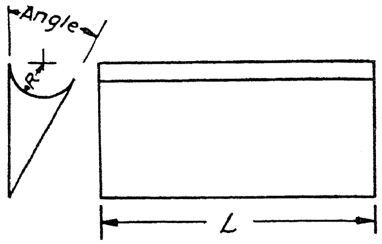
Values of C and K for Various Metals

Material	C	K
Cast Iron	2.57	1.636
Steel	2.80	1.780
Aluminum	.952	.606
Copper	3.14	2.00
Zinc	2.49	1.586
Gun Metal	3.11	1.980
Yellow Brass	2.98	1.900

To find the weight of a ring with a cross section as shown in Fig. 2, first find the sum of the radius of cross section multiplied by the height and the arc multiplied by the difference between the outside radius and radius of cross section. Then this sum multiplied by the thickness times the constant *K* is the weight required.

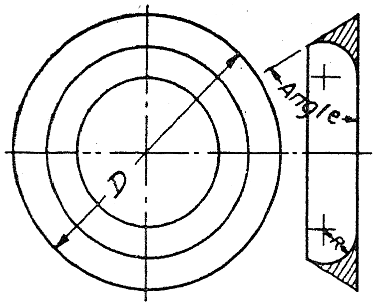
$$S=rH+a(R-r)$$
$$W=STK$$

WEIGHT OF FILLETS



To find the weight of a straight fillet, multiply the radius squared by the length, by the constant C, corresponding to the angle and material used. See page 103. The formula for finding the weight follows:

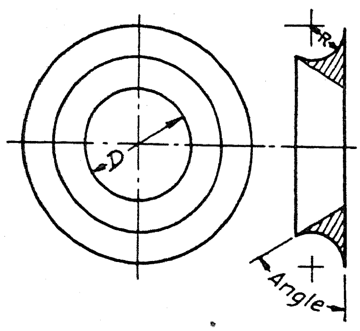
$$W = R^2 L C.$$



To find the weight of an inside circular fillet, multiply the difference between the diameter of the circle made by vertex and the product of the radius and the constant K, by the radius squared, by the constant M.

For constants K and M corresponding to the angle and material used see page 103. The formula for finding the weight follows:

$$W = (D - RK)\ R^2 M.$$



To find the weight of an outside circular fillet, multiply the sum of the diameter of a circle made by the vertex and the product of the radius and the constant K, by the radius squared, by the constant M.

For constants K and M corresponding to the angle and material used, see page 103. The formula for finding the weight follows:

$$W = (D + R\,K)\ R^2 M.$$

WEIGHT OF FILLETS
(Continued)

For fillets with an angle of 90 degrees use the formulas as follows:

Straight fillets, page 82.

Circular fillets, page 98.

The following tables are for use with the formulas given on page 102.

Material	Values of C When Angle of Fillet Is									
	15 Deg.	22½ Deg.	30 Deg.	45 Deg.	60 Deg.	75 Deg.	105 Deg.	120 Deg.	135 Deg.	150 Deg.
Cast iron	1.605	.950	.632	.322	.1785	.1009	.0294	.0140	.0056	.0016
Cast steel	1.745	1.003	.686	.350	.1940	.1094	.0319	.0152	.0061	.0017
Aluminum	.595	.352	.234	.119	.0662	.0384	.0118	.0051	.0021	.0006
Copper	1.975	1.168	.777	.396	.2195	.1240	.0362	.0172	.0069	.0019
Zinc	1.560	.921	.624	.313	.1735	.0976	.0286	.0136	.0054	.0015
Gun metal	1.951	1.155	.768	.392	.2170	.1225	.0356	.0170	.0068	.0019
Yellow Brass	1.875	1.118	.739	.376	.2085	.1178	.0344	.0164	.0064	.0018

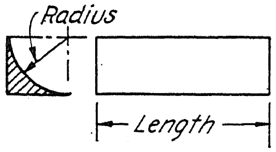
Material	Values of K When Angle of Fillet Is									
	15 Deg.	22½ Deg.	30 Deg.	45 Deg.	60 Deg.	75 Deg.	105 Deg.	120 Deg.	135 Deg.	150 Deg.
For any material	9.08	5.70	3.90	2.16	1.32	.750	.250	.225	.050	.020

Material	Values of M When Angle of Fillet Is									
	15 Deg.	22½ Deg.	30 Deg.	45 Deg.	60 Deg.	75 Deg.	105 Deg.	120 Deg.	135 Deg.	150 Deg.
Cast iron	5.04	2.99	1.98	1.012	.561	.317	.0925	.0440	.0176	.0050
Cast steel	5.46	3.25	2.16	1.100	.610	.344	.1005	.0478	.0191	.0054
Aluminum	1.87	1.11	.735	.386	.208	.118	.0343	.0163	.0065	.0019
Copper	6.20	3.66	2.44	1.245	.691	.390	.1138	.0541	.0216	.0062
Zinc	4.89	2.91	1.94	.982	.545	.308	.0899	.0427	.0171	.0049
Gun metal	6.12	3.64	2.41	1.238	.684	.386	.1128	.0535	.0214	.0061
Yellow brass	5.89	3.49	2.31	1.185	.646	.370	.1008	.0514	.0205	.0058

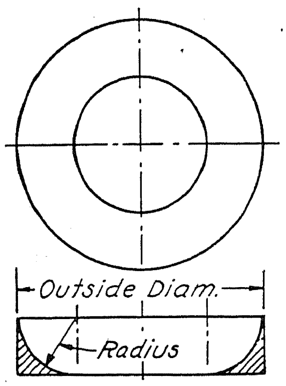
For Materials Not Given in Above Table,
C = Weight Per Cubic Inch Multiplied by k.
M = Weight Per Cubic Inch Multiplied by m.

Angle	15 Deg.	22½ Deg.	30 Deg.	45 Deg.	60 Deg.	75 Deg.	105 Deg.	120 Deg.	135 Deg.	150 Deg.
K	6.156	3.653	2.423	1.236	.6848	.3869	.1128	.0538	.0215	.0062
M	19.33	11.48	7.61	3.882	2.151	1.215	.3544	.1690	.0675	.0195

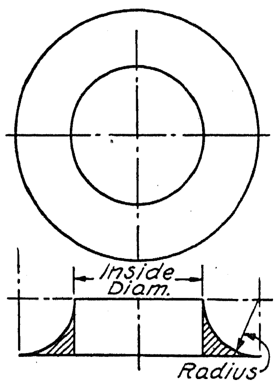
WEIGHT OF FILLETS
(Continued)



To find the weight of a fillet of any length multiply the weight per inch, obtained from the table on page 105, by the length.



To find the weight of an inside circular fillet, first find the circumference of a circle whose diameter is the outside diameter minus 0.45 of the radius. Then the weight required is this circumference multiplied by the weight per inch obtained from table on page 105.



To find the weight of an outside circular fillet, first find the circumference of a circle whose diameter is the inside diameter plus 0.45 of the radius. Then the weight required is this circumference multiplied by the weight per inch obtained from table on page 105.

WEIGHT OF FILLETS
(Concluded)

TABLE FOR COMPUTING WEIGHT OF FILLETS

For Method of Application, see page 104

Rad. in in.	Weight of Fillet 1 Inch Long When Cast in							Rad. in in.	Weight of Fillet 1 Inch Long When Cast in						
	Cast iron	Steel	Aluminum	Copper	Zinc	Gun metal	Yellow brass		Cast iron	Steel	Aluminum	Copper	Zinc	Gun metal	Yellow brass
¼	.0035	.0038	.0013	.0043	.0034	.0043	.0041	4⅝	1.20	1.30	.442	1.47	1.16	1.45	1.39
⅜	.0079	.0086	.0029	.0097	.0077	.0095	.0091	4¾	1.26	1.37	.467	1.55	1.23	1.53	1.47
½	.0140	.0152	.0052	.0172	.0136	.0170	.0163	4⅞	1.33	1.44	.492	1.63	1.29	1.61	1.55
⅝	.0219	.0238	.0081	.0266	.0222	.0265	.0254	5	1.40	1.52	.516	1.72	1.36	1.70	1.63
¾	.0315	.0342	.0116	.0386	.0307	.0381	.0367	5⅛	1.47	1.60	.544	1.80	1.43	1.78	1.71
⅞	.0440	.0466	.0158	.0526	.0416	.0520	.0498	5¼	1.54	1.68	.568	1.89	1.50	1.87	1.79
1	.0559	.0612	.0207	.0688	.0543	.0679	.0652	5⅜	1.62	1.76	.598	1.98	1.57	1.96	1.88
1⅛	.0710	.0772	.0262	.0871	.0688	.0857	.0823	5½	1.70	1.84	.626	2.08	1.64	2.05	1.97
1¼	.0876	.0954	.0322	.107	.0850	.106	.102	5⅝	1.78	1.93	.643	2.17	1.72	2.14	2.06
1⅜	.106	.115	.0390	.130	.103	.128	.123	5¾	1.86	2.02	.682	2.27	1.80	2.24	2.15
1½	.126	.137	.0465	.155	.122	.153	.147	5⅞	1.94	2.11	.713	2.37	1.88	2.34	2.24
1⅝	.148	.162	.0545	.181	.143	.179	.172	6	2.02	2.20	.742	2.47	1.96	2.44	2.34
1¾	.174	.186	.0634	.211	.166	.208	.200	6⅛	2.10	2.29	.773	2.58	2.04	2.54	2.44
1⅞	.197	.214	.0726	.242	.191	.239	.229	6¼	2.19	2.38	.805	2.68	2.12	2.65	2.54
2	.224	.244	.0826	.274	.217	.271	.260	6⅜	2.28	2.47	.838	2.79	2.21	2.75	2.65
2⅛	.253	.276	.0935	.310	.245	.304	.293	6½	2.37	2.57	.874	2.90	2.30	2.86	2.75
2¼	.285	.310	.105	.349	.274	.342	.328	6⅝	2.46	2.67	.906	3.02	2.38	2.97	2.85
2⅜	.325	.346	.117	.389	.307	.384	.367	6¾	2.55	2.78	.942	3.13	2.47	3.08	2.96
2½	.351	.383	.126	.430	.340	.425	.405	6⅞	2.65	2.89	.975	3.25	2.56	3.20	3.07
2⅝	.386	.423	.142	.474	.376	.468	.449	7	2.75	2.99	1.01	3.37	2.66	3.32	3.18
2¾	.425	.464	.156	.520	.412	.512	.493	7⅛	2.84	3.10	1.05	3.50	2.75	3.44	3.29
2⅞	.463	.505	.171	.568	.450	.558	.537	7¼	2.94	3.21	1.09	3.62	2.85	3.56	3.42
3	.504	.550	.186	.620	.488	.612	.586	7⅜	3.04	3.32	1.12	3.74	2.96	3.68	3.54
3⅛	.548	.597	.202	.672	.531	.662	.635	7½	3.15	3.43	1.16	3.86	3.06	3.82	3.66
3¼	.592	.645	.218	.726	.573	.715	.687	7⅝	3.26	3.54	1.20	3.99	3.16	3.94	3.78
3⅜	.638	.694	.236	.784	.620	.772	.742	7¾	3.37	3.66	1.24	4.12	3.26	4.07	3.91
3½	.686	.747	.254	.841	.666	.830	.797	7⅞	3.48	3.78	1.28	4.26	3.37	4.20	4.03
3⅝	.737	.800	.272	.905	.715	.890	.855	8	3.59	3.91	1.32	4.38	3.48	4.34	4.17
3¾	.789	.857	.289	.968	.765	.954	.915	8⅛	3.70	4.03	1.36	4.53	3.59	4.48	4.30
3⅞	.841	.916	.312	1.03	.815	1.02	.977	8¼	3.82	4.16	1.41	4.68	3.70	4.62	4.43
4	.896	.978	.330	1.10	.868	1.08	1.04	8⅜	3.93	4.28	1.45	4.81	3.81	4.76	4.57
4⅛	.944	1.04	.352	1.17	.922	1.15	1.11	8½	4.05	4.40	1.50	4.95	3.92	4.90	4.71
4¼	1.01	1.10	.374	1.24	.980	1.22	1.17	8⅝	4.17	4.53	1.54	5.10	4.04	5.04	4.84
4⅜	1.07	1.16	.396	1.31	1.04	1.30	1.25	8¾	4.29	4.67	1.58	5.26	4.16	5.19	4.98
4½	1.14	1.23	.418	1.39	1.10	1.37	1.32	8⅞	4.42	4.81	1.63	5.42	4.28	5.34	5.12

PERIMETER OR GIRTH TABLE FOR DETERMINING THE WEIGHT OF IRON CASTINGS

Examples Showing How To Use the Table

No. 1.—Find the weight of an irregularly shaped casting as shown in Fig. 1. Its perimeter or girth measured with a piece of cord along *A, B, C,* the center of its section is 27 inches; the thickness of the casting is ½ inch; the total length of casting is 6 feet 2 inches.

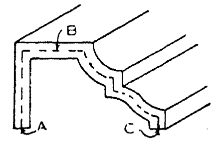


FIG. 1

From table, page 107.

Pounds.

27-in. girth x ½-in. thick per ft. l'gth =42.12

Therefore

27-in. girth x ½-in. thick per 6 ft. =42.12 × 6 = 252.72

and

27-in. girth x ½-in. thick per 2 in. =42.12 ÷ 6 = 7.02

Weight of casting = 252.72 lbs. + 7.02 lbs. = 259.74 lbs.

No. 2.—Find the weight of a cast iron plate as shown in Fig. 2.

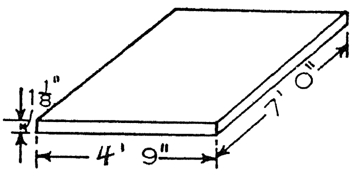


FIG. 2

From table, page 107.

29-in. girth x 9/16 in. thick = 50.90 lbs. per ft.
28-in. girth x 9/16-in. thick = 49.14 lbs. per ft.
57-in. girth x 9/16 in. thick = 100.04 lbs. per ft.

Therefore 57-in. girth x 1 1/8 in. thick = 200.08 lbs. per ft. or

57-in. girth x 1 1/8-in. thick=100.04 lbs. × 2=200.08 lbs. per ft.
Weight of casting = 200.08 lbs. × 7 = 1,400.56 lbs.

Example No. 2 is given to show how table may be extended to thicknesses of metal not given in it.

TABLE OF WEIGHTS OF CASTINGS

THICKNESS OF METAL IN INCHES

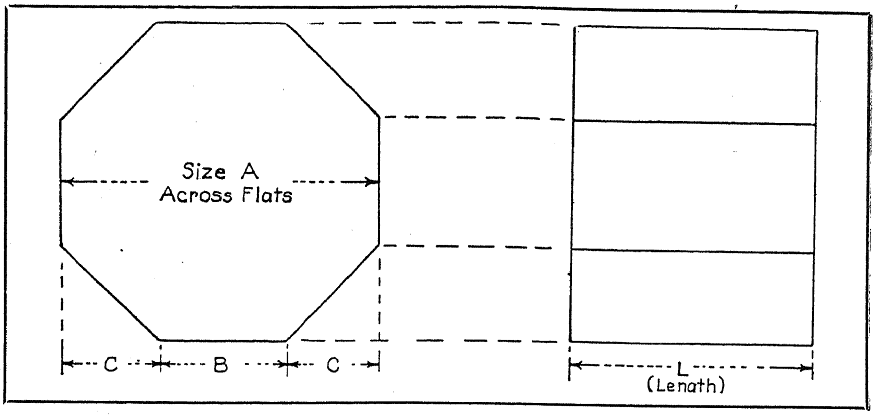
Weight in Pounds per 1 Foot in Length

Girth, in.	1/8	5/32	3/16	7/32	1/4	9/32	5/16	11/32	3/8	13/32	7/16	15/32	1/2	17/32	9/16	19/32	5/8	Girth, in.
1/4	0.098	0.122	0.146	0.171	0.195	0.219	0.244	0.268	0.293	0.317	0.341	0.366	0.390	0.415	0.439	0.463	0.488	1/4
1/2	0.195	0.244	0.293	0.341	0.390	0.439	0.488	0.536	0.585	0.634	0.683	0.731	0.780	0.829	0.878	0.926	0.975	1/2
1	0.39	0.49	0.585	0.683	0.78	0.878	0.975	1.07	1.17	1.27	1.37	1.46	1.56	1.658	1.76	1.85	1.95	1
2	0.78	0.98	1.17	1.37	1.56	1.76	1.95	2.15	2.34	2.54	2.73	2.93	3.12	3.315	3.51	3.71	3.90	2
3	1.17	1.46	1.76	2.05	2.34	2.63	2.93	3.22	3.51	3.80	4.10	4.39	4.68	4.97	5.27	5.56	5.85	3
4	1.56	1.95	2.34	2.73	3.12	3.51	3.90	4.29	4.68	5.07	5.46	5.85	6.24	6.63	7.02	7.41	7.80	4
5	1.95	2.44	2.93	3.41	3.90	4.39	4.88	5.36	5.85	6.34	6.83	7.31	7.80	8.29	8.78	9.26	9.75	5
6	2.34	2.93	3.51	4.10	4.68	5.27	5.85	6.44	7.02	7.61	8.19	8.78	9.36	9.95	10.53	11.12	11.70	6
7	2.73	3.41	4.10	4.78	5.46	6.14	6.83	7.51	8.19	8.87	9.56	10.24	10.92	11.60	12.29	12.97	13.65	7
8	3.12	3.90	4.68	5.46	6.24	7.02	7.80	8.58	9.36	10.14	10.92	11.70	12.48	13.26	14.04	14.82	15.60	8
9	3.51	4.39	5.27	6.14	7.02	7.90	8.78	9.65	10.53	11.41	12.29	13.16	14.04	14.92	15.80	16.67	17.55	9
10	3.90	4.88	5.85	6.83	7.80	8.78	9.75	10.73	11.70	12.68	13.65	14.63	15.60	16.58	17.55	18.53	19.50	10
11	4.29	5.36	6.44	7.51	8.58	9.65	10.73	11.80	12.87	13.94	15.02	16.09	17.16	18.23	19.31	20.38	21.45	11
12	4.68	5.85	7.02	8.19	9.36	10.53	11.70	12.87	14.04	15.21	16.38	17.55	18.72	19.89	21.06	22.23	23.40	12
13	5.07	6.34	7.61	8.87	10.14	11.41	12.68	13.94	15.21	16.48	17.75	19.01	20.28	21.55	22.82	24.08	25.35	13
14	5.46	6.82	8.19	9.56	10.92	12.29	13.65	15.02	16.38	17.75	19.11	20.48	21.84	23.21	24.57	25.94	27.30	14
15	5.85	7.31	8.78	10.24	11.70	13.16	14.63	16.09	17.55	19.01	20.48	21.94	23.40	24.86	26.33	27.79	29.25	15
16	6.24	7.80	9.36	10.92	12.48	14.04	15.60	17.16	18.72	20.28	21.84	23.40	24.96	26.52	28.08	29.64	31.20	16
17	6.63	8.29	9.95	11.60	13.26	14.92	16.58	18.23	19.89	21.55	23.21	24.86	26.52	28.18	29.84	31.49	33.15	17
18	7.02	8.78	10.53	12.29	14.04	15.80	17.55	19.31	21.06	22.82	24.57	26.33	28.08	29.84	31.59	33.35	35.10	18
19	7.41	9.26	11.12	12.97	14.82	16.67	18.53	20.38	22.23	24.08	25.93	27.79	29.64	31.49	33.35	35.20	37.05	19
20	7.80	9.75	11.70	13.65	15.60	17.55	19.50	21.45	23.40	25.35	27.30	29.25	31.20	33.15	35.10	37.05	39.00	20
21	8.19	10.24	12.29	14.33	16.38	18.43	20.48	22.52	24.57	26.62	28.67	30.71	32.76	34.81	36.86	38.90	40.95	21
22	8.58	10.73	12.87	15.02	17.16	19.31	21.45	23.60	25.74	27.89	30.03	32.18	34.32	36.47	38.61	40.76	42.90	22
23	8.97	11.21	13.46	15.70	17.94	20.18	22.43	24.67	26.91	29.15	31.40	33.64	35.88	38.12	40.37	42.61	44.85	23
24	9.36	11.70	14.04	16.38	18.72	21.06	23.40	25.74	28.08	30.42	32.76	35.10	37.44	39.78	42.12	44.46	46.80	24
25	9.75	12.19	14.63	17.06	19.50	21.94	24.38	26.81	29.29	31.69	34.13	36.56	39.00	41.44	43.88	46.31	48.75	25
26	10.14	12.68	15.21	17.75	20.28	22.82	25.35	27.89	30.42	32.96	35.49	38.03	40.56	43.10	45.63	48.17	50.70	26
27	10.53	13.16	15.80	18.43	21.06	23.69	26.33	28.97	31.59	34.22	36.86	39.49	42.12	44.75	47.39	50.02	52.65	27
28	10.92	13.65	16.38	19.11	21.84	24.57	27.30	30.03	32.76	35.49	38.22	40.95	43.68	46.41	49.14	51.87	54.60	28
29	11.31	14.14	16.97	19.79	22.62	25.45	28.28	31.10	33.93	36.76	39.59	42.41	45.24	48.07	50.90	53.72	56.55	29
30	11.70	14.63	17.55	20.48	23.40	26.33	29.25	32.18	35.10	38.03	40.95	43.88	46.80	49.73	52.65	55.58	58.50	30
31	12.09	15.11	18.14	21.16	24.18	27.20	30.23	33.25	36.27	39.29	42.32	45.34	48.36	51.38	54.41	57.43	60.45	31
32	12.48	15.60	18.72	21.84	24.96	28.08	31.20	34.32	37.44	40.56	43.68	46.80	49.92	53.04	56.16	59.28	62.40	32
64	24.96	31.20	37.44	43.68	49.92	56.16	62.40	68.64	74.88	81.12	87.36	93.60	99.84	106.08	112.32	118.46	124.80	64

If the above weights, which are for cast iron, be multiplied by: 1.08 it will give the weight of a similar casting in wrought iron or steel; 1.154 it will give the weight of a similar casting in brass; 1.54 it will give the weight of a similar casting in lead; 0.36 it will give the weight of a similar casting in aluminum.

For method of interpolation, see page 82.

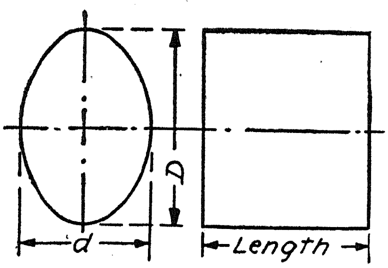
WEIGHTS OF SOLID OCTAGONAL IRON CASTINGS



HANDY FORMULAS RELATING TO OCTAGONS

Given	Required	Formulas
A	B	$A \times 0.4142$
A	C	$\sqrt{\dfrac{(A \times 0.4142)^2}{2}}$
B	A	$\dfrac{B}{0.4142}$
B	C	$\sqrt{\dfrac{B^2}{2}}$
C	A	$\dfrac{\sqrt{2C^2}}{0.4142}$
C	B	$\sqrt{2C^2}$
A	Area of End	$A^2 \times 0.8284$
A and L	Weight in lbs.	$A^2 \times 0.8284 \times L \times$ weight of a cubic inch of the material

WEIGHT OF ELLIPTICAL BARS PER RUNNING INCH



The following tables give the weights of ellipitical bars of cast iron, steel, aluminum, copper, zinc, gun metal and yellow brass in one-inch lengths. To find the wegiht of an elliptical bar of these materials of any given length, multiply the weight per running inch from the tables by the total length of the bar in inches.

Weight of Bar 1 Inch Long When Cast in

d	D	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yellow brass
¾	1	.153	.167	.057	.188	.149	.186	.178
¾	1¼	.192	.209	.071	.235	.186	.232	.223
¾	1½	.230	.251	.085	.283	.223	.279	.268
¾	1¾	.268	.292	.099	.330	.260	.325	.312
¾	2	.307	.334	.113	.377	.297	.371	.357
¾	2¼	.345	.376	.128	.424	.335	.418	.401
¾	2½	.383	.418	.142	.471	.372	.464	.446
¾	2¾	.422	.460	.156	.518	.409	.511	.491
¾	3	.460	.501	.170	.565	.446	.557	.535
1	1¼	.256	.278	.095	.313	.248	.309	.297
1	1½	.307	.334	.114	.375	.297	.371	.356
1	1¾	.358	.389	.133	.438	.347	.433	.416
1	2	.409	.445	.152	.500	.397	.495	.475
1	2¼	.460	.501	.170	.564	.446	.557	.535
1	2½	.511	.556	.190	.625	.496	.619	.594
1	2¾	.562	.612	.209	.688	.545	.681	.653
1	3	.613	.667	.228	.750	.595	.743	.712
1	3½	.716	.779	.265	.875	.694	.866	.851
1	4	.818	.890	.303	1.00	.793	.990	.950
1¼	1½	.384	.418	.142	.471	.372	.464	.446
1¼	1¾	.448	.487	.166	.548	.434	.542	.519
1¼	2	.512	.556	.190	.625	.496	.619	.594
1¼	2¼	.576	.626	.212	.705	.558	.697	.668
1¼	2½	.640	.694	.236	.784	.620	.774	.742
1¼	2¾	.704	.764	.259	.862	.682	.851	.816
1¼	3	.768	.833	.283	.941	.744	.929	.890

Weight of Bar 1 Inch Long When Cast in

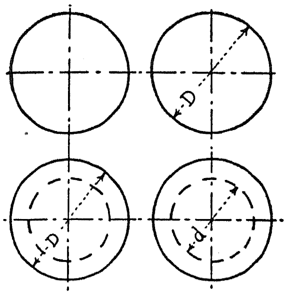
d	D	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yellow brass
1¼	3½	.896	.971	.331	1.10	.868	1.08	1.04
1¼	4	1.02	1.11	.378	1.25	.992	1.24	1.19
1¼	4½	1.15	1.25	.425	1.41	1.12	1.39	1.34
1¼	5	1.28	1.39	.473	1.57	1.24	1.55	1.48
1½	1¾	.537	.585	.198	.659	.520	.650	.624
1½	2	.613	.667	.227	.753	.595	.743	.713
1½	2¼	.690	.752	.255	.848	.669	.835	.803
1½	2½	.767	.835	.283	.942	.743	.928	.892
1½	2¾	.843	.919	.312	1.04	.818	1.02	.981
1½	3	.920	1.00	.340	1.13	.892	1.11	1.07
1½	3½	1.07	1.17	.397	1.32	1.04	1.30	1.25
1½	4	1.23	1.34	.453	1.51	1.19	1.49	1.43
1½	4½	1.38	1.50	.510	1.69	1.34	1.67	1.61
1½	5	1.53	1.67	.567	1.88	1.49	1.86	1.78
1½	5½	1.69	1.84	.624	2.07	1.63	2.04	1.96
1½	6	1.84	2.01	.681	2.26	1.78	2.23	2.14
2	2½	1.02	1.11	.378	1.25	.992	1.24	1.19
2	3	1.23	1.34	.455	1.51	1.19	1.49	1.43
2	3½	1.43	1.56	.530	1.76	1.39	1.73	1.66
2	4	1.64	1.78	.606	2.01	1.59	1.98	1.90
2	4½	1.84	2.01	.681	2.26	1.78	2.23	2.14
2	5	2.05	2.23	.758	2.51	1.98	2.48	2.38
2	5½	2.25	2.45	.833	2.76	2.18	2.72	2.61
2	6	2.46	2.67	.909	3.01	2.38	2.97	2.85
2	7	2.86	3.12	1.06	3.51	2.78	3.47	3.33
2	8	3.27	3.57	1.21	4.01	3.17	3.96	3.80

WEIGHT OF ELLIPTICAL BARS PER RUNNING INCH
(Concluded)

d	D	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yellow brass
		Weight of Bar 1 Inch Long When Cast in						
2½	3	1.53	1.67	.567	1.88	1.49	1.86	1.78
2½	3½	1.79	1.95	.662	2.19	1.74	2.17	2.08
2½	4	2.05	2.23	.756	2.51	1.98	2.48	2.38
2½	4½	2.30	2.50	.851	2.82	2.23	2.79	2.67
2½	5	2.56	2.78	.955	3.14	2.47	3.10	2.97
2½	5½	2.81	3.06	1.05	3.45	2.72	3.40	3.26
2½	6	3.06	3.34	1.14	3.77	2.97	3.71	3.56
2½	7	3.57	3.90	1.33	4.40	3.47	4.33	4.15
2½	8	4.08	4.45	1.52	5.02	3.97	4.95	4.75
2½	9	4.59	5.01	1.71	5.65	4.46	5.57	5.34
2½	10	5.11	5.56	1.89	6.27	4.96	6.19	5.94
3	3½	2.14	2.34	.797	2.63	2.08	2.60	2.49
3	4	2.46	2.67	.909	3.01	2.38	2.97	2.85
3	4½	2.76	3.01	1.02	3.39	2.68	3.34	3.21
3	5	3.06	3.34	1.13	3.76	2.98	3.71	3.56
3	5½	3.37	3.68	1.25	4.14	3.27	4.08	3.92
3	6	3.68	4.01	1.36	4.52	3.57	4.45	4.28
3	7	4.29	4.68	1.58	5.27	4.16	5.19	4.99
3	8	4.90	5.35	1.81	6.02	4.76	5.93	5.71
3	9	5.52	6.01	2.03	6.77	5.35	6.68	6.42
3	10	6.13	6.68	2.26	7.53	5.95	7.42	7.13
3	11	6.74	7.35	2.49	8.28	6.54	8.16	7.84
3	12	7.36	8.01	2.72	9.03	7.14	8.91	8.55
3½	4	2.86	3.12	1.06	3.51	2.78	3.47	3.33
3½	4½	3.22	3.51	1.19	3.95	3.13	3.91	3.74
3½	5	3.57	3.90	1.33	4.40	3.47	4.33	4.15
3½	5½	3.93	4.29	1.46	4.83	3.81	4.76	4.57
3½	6	4.29	4.69	1.58	5.27	4.16	5.19	4.99
3½	7	5.01	5.47	1.84	6.15	4.86	6.05	5.82
3½	8	5.72	6.24	2.11	7.02	5.55	6.92	6.66
3½	9	6.44	7.01	2.39	7.90	6.25	7.79	7.49
3½	10	7.15	7.78	2.65	8.79	6.94	8.67	8.32
3½	11	7.87	8.56	2.91	9.66	7.64	9.54	9.15

d	D	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yellow brass
		Weight of Bar 1 Inch Long When Cast in						
3½	12	8.58	9.34	3.17	10.53	8.33	10.40	9.97
4	4½	3.68	4.01	1.36	4.51	3.57	4.46	4.28
4	5	4.08	4.45	1.52	5.02	3.97	4.95	4.75
4	5½	4.49	4.90	1.67	5.52	4.36	5.44	5.23
4	6	4.00	5.35	1.81	6.02	4.76	5.93	5.71
4	7	5.72	6.24	2.11	7.02	5.55	6.92	6.66
4	8	6.54	7.13	2.42	8.03	6.35	7.92	7.61
4	9	7.36	8.01	2.72	9.03	7.14	8.91	8.55
4	10	8.17	8.89	3.02	10.03	7.94	9.91	9.50
4	11	8.99	9.78	3.33	11.04	8.73	10.90	10.45
4	12	9.81	10.68	3.63	12.04	9.52	11.89	11.40
4½	5	4.59	5.01	1.71	5.65	4.46	5.57	5.34
4½	5½	5.06	5.51	1.88	6.21	4.91	6.12	5.87
4½	6	5.52	6.01	2.05	6.77	5.35	6.68	6.42
4½	7	6.44	7.01	2.39	7.90	6.25	7.79	7.49
4½	8	7.36	8.01	2.72	9.03	7.14	8.91	8.55
4½	9	8.28	9.01	3.06	10.16	8.03	10.02	9.62
4½	10	9.19	10.01	3.40	11.29	8.93	11.14	10.69
4½	11	10.11	11.01	3.74	12.42	9.82	12.25	11.76
4½	12	11.04	12.02	4.08	13.54	10.71	13.37	12.82
5	6	6.13	6.67	2.27	7.53	5.95	7.43	7.13
5	7	7.15	7.78	2.65	8.79	6.94	8.67	8.32
5	8	8.17	8.89	3.02	10.03	7.94	9.91	9.51
5	9	9.19	10.01	3.40	11.29	8.93	11.14	10.69
5	10	10.22	11.12	3.78	12.54	9.92	12.38	11.88
5	11	11.24	12.23	4.16	13.79	10.91	13.62	13.07
5	12	12.27	13.35	4.54	15.05	11.90	14.86	14.25
6	7	8.58	9.34	3.17	10.53	8.33	10.40	9.97
6	8	9.81	10.68	3.63	12.04	9.52	11.89	11.40
6	9	11.04	12.02	4.08	13.54	10.71	13.37	12.82
6	10	12.27	13.35	4.54	15.05	11.90	14.86	14.25
6	11	13.49	14.69	5.00	16.56	13.09	16.34	15.67
6	12	14.72	16.02	5.45	18.07	14.28	17.83	17.10

WEIGHT OF BALLS OR SPHERES



In the accompanying tables are given the weight of balls or spheres in pounds for different diameters *D*.

To find the weight of a hollow ball, subtract the weight corresponding to the inside diameter *d* from the weight corresponding to the outside diameter *D*.

Weight of Ball or Sphere When Cast in

Dia. in in.	Cast iron	Steel	Aluminum	Copper	Zinc	Gun metal	Yellow brass
⅜	.007	.008	.003	.009	.007	.009	.008
½	.017	.019	.006	.021	.017	.021	.020
⅝	.033	.036	.012	.041	.032	.040	.039
¾	.058	.063	.021	.071	.056	.070	.067
⅞	.091	.099	.034	.112	.089	.111	.106
1	.136	.148	.050	.167	.132	.165	.158
1⅛	.194	.212	.072	.238	.189	.235	.226
1¼	.267	.290	.098	.223	.259	.319	.310
1⅜	.354	.385	.131	.435	.345	.429	.413
1½	.460	.500	.170	.564	.446	.556	.535
1⅝	.586	.636	.217	.717	.569	.707	.680
1¾	.732	.795	.271	.896	.721	.884	.851
1⅞	.900	.976	.332	1.10	.873	1.09	1.05
2	1.09	1.19	.404	1.34	1.06	1.32	1.27
2⅛	1.31	1.42	.484	1.60	1.27	1.58	1.52
2¼	1.56	1.69	.575	1.91	1.51	1.88	1.81
2⅜	1.83	1.99	.675	2.24	1.77	2.21	2.12
2½	2.13	2.32	.788	2.60	2.07	2.56	2.48
2⅝	2.47	2.68	.914	3.02	2.40	2.93	2.87
2¾	2.84	3.06	1.05	3.47	2.76	3.42	3.30
2⅞	3.24	3.52	1.20	3.93	3.15	3.92	3.78
3	3.68	4.00	1.36	4.51	3.57	4.45	4.29
3⅛	4.16	4.52	1.54	5.10	4.05	5.03	4.84
3¼	4.68	5.09	1.73	5.73	4.55	5.65	5.44
3⅜	5.25	5.70	1.94	6.19	5.09	6.34	6.10
3½	5.86	6.36	2.17	7.16	5.69	7.06	6.82
3⅝	6.50	7.06	2.40	7.96	6.31	7.85	7.55
3¾	7.20	7.83	2.66	8.84	7.00	8.70	8.37
3⅞	7.95	8.64	2.94	9.74	7.71	9.60	9.24

Weight of Ball or Sphere When Cast in

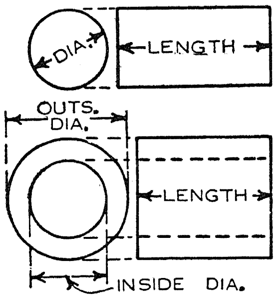
Dia. in in.	Cast iron	Steel	Aluminum	Copper	Zinc	Gun metal	Yellow brass
4	8.74	9.50	3.23	10.7	8.48	10.6	10.1
4⅛	9.57	10.4	3.54	11.7	9.30	11.6	11.1
4¼	10.5	11.4	3.87	12.8	10.2	12.7	12.1
4⅜	11.4	12.4	4.22	13.9	11.1	13.8	13.3
4½	12.4	13.5	4.60	15.3	12.1	15.1	14.4
4⅝	13.5	14.7	4.99	16.6	13.1	16.4	15.7
4¾	14.6	15.9	5.41	17.9	14.2	17.7	17.0
4⅞	15.8	17.2	5.84	19.4	15.3	19.1	18.3
5	17.1	18.5	6.30	20.9	16.6	20.6	19.8
5⅛	18.4	19.9	6.78	22.5	17.8	22.2	21.3
5¼	19.8	21.5	7.30	24.2	19.2	23.9	22.9
5⅜	21.2	23.0	7.83	25.9	20.6	25.6	24.6
5½	22.8	24.7	8.40	27.9	22.0	27.5	26.4
5⅝	24.3	26.2	9.98	29.8	23.6	29.4	28.2
5¾	26.0	28.2	9.60	31.8	25.2	31.4	30.2
5⅞	27.6	30.0	10.2	33.9	26.8	33.4	32.2
6	29.7	32.0	10.9	36.1	28.6	35.6	34.3
6⅛	31.4	34.1	11.6	38.4	30.5	37,9	36.5
6¼	33.2	36.2	12.3	40.8	32.3	40.2	38.7
6⅜	35.4	38.4	13.1	43.2	34.3	42.6	41.1
6½	37.4	40.7	13.8	45.8	36.4	45.2	43.5
6⅝	39.7	43.1	14.7	48.7	38.6	48.0	46.2
6¾	42.0	45.7	15.5	51.5	40.8	50.8	48.9
7⅞	44.4	48.2	16.4	54.4	43.1	53.6	51.6
7	46.8	50.9	17.3	57.3	45.4	56.5	54.5
7⅛	49.4	53.7	18.3	60.5	48.0	59.6	57.4
7¼	52.0	56.5	19.2	63.7	50.5	62.8	60.5
7⅜	54.8	59.6	20.2	67.1	53.1	66.2	63.8
7½	57.5	62.6	21.3	70.5	56.0	69.5	67.0

WEIGHT OF BALLS OR SPHERES
(Concluded)

	Weight of Ball or Sphere When Cast in						
Dia. in in.	Cast iron	Steel	Alumi-num	Cop-per	Zinc	Gun met-al	Yel-low brass
7⅝	60.6	65.8	22.4	74.1	58.8	73.1	70.4
7¾	63.5	69.0	23.4	77.7	61.5	76.6	73.7
7⅞	66.6	72.4	24.6	81.5	64.6	80.4	78.5
8	70.0	76.0	25.8	85.7	68.0	84.5	81.4
8⅛	73.2	79.6	27.1	89.8	71.1	88.5	85.1
8¼	76.7	83.4	28.4	94.0	74.5	92.6	89.2
8⅜	80.0	87.0	29.6	98.0	77.8	96.6	93.1
8½	83.7	91.0	31.0	103	81.4	101	97.5
8⅝	87.5	95.0	32.4	107	85.0	106	102
8¾	91.5	99.5	33.8	113	88.8	111	106
8⅞	95.5	104	35.3	118	92.5	116	111
9	99.5	108	36.8	122	96.5	120	115
9⅛	104	113	38.3	127	100	125	120
9¼	108	117	39.8	133	105	131	125
9⅜	112	122	41.5	138	109	136	130
9½	117	127	43.2	144	114	142	136
9⅝	122	132	45.0	149	118	147	141
9¾	127	138	46.8	155	123	153	147
9⅞	131	143	48.5	161	127	159	153
10	136	148	50.4	167	132	165	159
10⅛	141	154	52.4	173	137	171	164
10¼	147	159	54.3	180	142	178	170
10⅜	152	165	56.2	186	148	184	177
10½	158	172	58.3	194	153	191	184
10⅝	164	178	60.4	201	159	198	190
10¾	170	184	63.0	209	165	206	197
10⅞	175	191	64.8	215	170	212	204
11	182	197	67.0	223	176	220	211
11⅛	188	204	69.5	231	182	223	218
11¼	195	212	71.9	239	189	236	226
11⅜	201	218	74.3	246	196	243	234
11½	208	226	76.6	256	202	252	241
11⅝	216	234	79.5	264	208	260	250
11¾	221	240	81.5	272	215	268	257
11⅞	228	248	84.3	280	222	276	266
12	236	256	87.0	289	229	285	274
12¼	251	273	92.6	307	243	303	292
12½	267	287	98.5	323	259	319	307

	Weight of Ball or Sphere When Cast in						
Dia. in in	Cast iron	Steel	Alumi-num	Cop-per	Zinc	Gun met-al	Yel-low brass
12¾	283	308	105	347	274	342	328
13	300	326	111	367	291	362	348
13¼	315	344	117	388	308	383	369
13½	335	364	124	411	326	405	390
13¾	355	386	131	435	344	429	413
14	374	407	138	458	363	452	435
14¼	395	429	146	484	383	477	459
14½	416	452	154	509	404	502	484
14¾	438	476	162	538	425	530	509
15	460	500	170	564	447	556	535
15¼	484	525	179	592	470	584	562
15½	507	552	188	623	493	614	590
15¾	534	580	197	654	518	645	620
16	560	609	207	686	543	676	650
16¼	586	636	217	717	568	707	681
16½	613	666	226	751	595	740	712
16¾	641	696	237	786	622	775	745
17	670	729	248	822	650	810	780
17¼	700	760	259	858	681	846	815
17½	732	795	270	897	710	884	850
17¾	764	829	282	935	741	922	887
18	795	864	294	974	772	960	924
18¼	830	901	307	1,013	806	1,001	965
18½	864	938	320	1,058	839	1,044	1,002
18¾	900	977	332	1,102	873	1,088	1,045
19	936	1,013	346	1,149	909	1,130	1,088
19¼	974	1,058	360	1,190	945	1,173	1,130
19½	1,012	1,100	375	1,240	983	1,224	1,178
19¾	1,051	1,142	389	1,290	1,021	1,270	1,220
20	1,091	1,188	404	1,340	1,060	1,320	1,270
20½	1,178	1,278	435	1,441	1,140	1,420	1,363
21	1,262	1,371	467	1,549	1,225	1,525	1,467
21½	1,360	1,475	503	1,665	1,318	1,641	1,580
22	1,453	1,580	538	1,781	1,411	1,758	1,690
22½	1,555	1,689	575	1,908	1,509	1,880	1,810
23	1,662	1,808	614	2,040	1,611	2,005	1,930
23½	1,770	1,920	654	2,166	1,718	2,140	2,054
24	1,885	2,048	696	2,310	1,828	2,280	2,188

WEIGHT OF RODS OR CYLINDERS PER RUNNING INCH



Below is given the weights of rods or cylinders of different materials, 1 inch long. To find the weight of a cylinder of any length multiply the weight per running inch obtained from the table below by the length.

To find the weight of a tube of any length, subtract the weight per running inch corresponding to the inside diameter from the weight per running inch corresponding to the outside diameter, and then multiply this result by the length. This product is the weight required.

	Weight of Rod or Cylinder 1 Inch Long When Cast in						
Dia. in inches	Cast iron	Steel	Alumi-num	Copper	Zinc	Gun metal	Yellow brass
⅜	.0288	.0313	.0106	.0353	.0279	.0348	.0334
½	.0511	.0556	.0189	.0627	.0496	.0619	.0594
⅝	.0799	.0869	.0295	.0980	.0775	.0967	.0928
¾	.115	.125	.0425	.141	.112	.139	.134
⅞	.157	.170	.0579	.192	.152	.190	.182
1	.204	.223	.0756	.251	.198	.248	.238
1⅛	.259	.282	.0957	.318	.251	.313	.301
1¼	.320	.348	.118	.392	.310	.387	.371
1⅜	.387	.421	.148	.474	.375	.468	.449
1½	.460	.501	.170	.565	.446	.557	.535
1⅝	.540	.588	.200	.663	.524	.654	.627
1¾	.626	.681	.232	.769	.607	.758	.728
1⅞	.719	.782	.266	.882	.697	.871	.835
2	.818	.890	.303	1.00	.793	.990	.950
2⅛	.924	1.01	.342	1.13	.895	1.11	1.07
2¼	1.04	1.13	.383	1.27	1.00	1.25	1.20
2⅜	1.15	1.26	.427	1.42	1.12	1.40	1.34
2½	1.28	1.39	.473	1.57	1.24	1.55	1.48
2⅝	1.41	1.54	.521	1.73	1.37	1.71	1.64
2¾	1.55	1.69	.572	1.90	1.50	1.87	1.80
2⅞	1.69	1.84	.625	2.07	1.64	2.04	1.96
3	1.84	2.01	.681	2.26	1.78	2.23	2.14
3⅛	2.00	2.18	.739	2.45	1.94	2.42	2.32
3¼	2.16	2.35	.799	2.65	2.09	2.61	2.51
3⅜	2.33	2.53	.862	2.86	2.26	2.82	2.71
3½	2.51	2.73	.927	3.07	2.43	3.03	2.91
3⅝	2.69	2.92	.994	3.30	2.61	3.25	3.12
3¾	2.88	3.13	1.06	3.53	2.79	3.48	3.34
3⅞	3.07	3.34	1.14	3.77	2.97	3.72	3.57
4	3.27	3.57	1.21	4.01	3.17	3.96	3.80

	Weight of Rod or Cylinder 1 Inch Long When Cast in						
Dia. in inches	Cast iron	Steel	Alumi-num	Copper	Zinc	Gun metal	Yellow brass
4⅛	3.48	3.79	1.29	4.27	3.37	4.21	4.04
4¼	3.69	4.02	1.37	4.53	3.58	4.47	4.29
4⅜	3.91	4.26	1.45	4.80	3.80	4.74	4.55
4½	4.14	4.51	1.53	5.08	4.02	5.01	4.81
4⅝	4.37	4.76	1.62	5.37	4.24	5.30	5.08
4¾	4.61	5.02	1.71	5.66	4.47	5.59	5.36
4⅞	4.86	5.29	1.80	5.96	4.71	5.88	5.65
5	5.11	5.56	1.89	6.27	4.96	6.19	5.94
5⅛	5.37	5.84	1.99	6.59	5.21	6.50	6.24
5¼	5.64	6.13	2.08	6.92	5.47	6.83	6.55
5⅜	5.91	6.43	2.19	7.25	5.73	7.15	6.86
5½	6.19	6.73	2.29	7.59	6.00	7.49	7.19
5⅝	6.47	7.04	2.39	7.94	6.27	7.83	7.52
5¾	6.76	7.36	2.50	8.30	6.56	8.19	7.85
5⅞	7.06	7.68	2.61	8.66	6.84	8.54	8.20
6	7.36	8.01	2.72	9.03	7.14	8.91	8.55
6⅛	7.67	8.35	2.83	9.41	7.44	9.28	8.91
6¼	7.99	8.69	2.95	9.80	7.75	9.67	9.28
6⅜	8.31	9.04	3.07	10.20	8.06	10.06	9.65
6½	8.64	9.40	3.20	10.60	8.38	10.46	10.04
6⅝	8.98	9.77	3.32	11.01	8.70	10.86	10.43
6¾	9.32	10.14	3.45	11.43	9.04	11.28	10.82
6⅞	9.67	10.52	3.57	11.86	9.37	11.70	11.23
7	10.02	10.90	3.71	12.30	9.72	12.13	11.64
7⅛	10.38	11.30	3.84	12.74	10.07	12.57	12.06
7¼	10.75	11.70	3.98	13.19	10.42	13.01	12.49
7⅜	11.12	12.10	4.11	13.65	10.79	13.47	12.92
7½	11.50	12.52	4.25	14.11	11.16	13.92	13.36
7⅝	11.89	12.94	4.40	14.59	11.53	14.39	13.81
7¾	12.28	13.36	4.54	15.07	11.91	14.87	14.27

WEIGHT OF RODS OR CYLINDERS PER RUNNING INCH

(Continued)

Weight of Rod or Cylinder 1 Inch Long When Cast in

Dia. in inches	Cast Iron	Steel	Alum-num	Copper	Zinc	Gun metal	Yellow Brass
7⅞	12.68	13.80	4.69	15.56	12.30	15.35	14.73
8	13.09	14.24	4.84	16.06	12.69	15.84	15.20
8⅛	13.50	14.69	4.99	16.57	13.09	16.35	15.68
8¼	13.92	15.14	5.15	17.08	13.50	16.85	16.17
8⅜	14.34	15.61	5.30	17.60	13.91	17.36	16.66
8½	14.78	16.08	5.47	18.13	14.33	17.89	17.17
8⅝	15.21	16.55	5.63	18.67	14.75	18.42	17.67
8¾	15.66	17.04	5.79	19.21	15.18	18.95	18.19
8⅞	16.11	17.53	5.96	19.77	15.62	19.50	18.71
9	16.57	18.02	6.13	20.33	16.06	20.06	19.24
9⅛	17.03	18.53	6.30	20.89	16.51	20.61	19.78
9¼	17.50	19.04	6.47	21.47	16.97	21.18	20.33
9⅜	17.98	19.56	6.65	22.05	17.43	21.76	20.88
9½	18.46	20.08	6.83	22.65	17.90	22.35	21.44
9⅝	18.95	20.61	7.01	23.25	18.37	22.94	22.01
9¾	19.44	21.15	7.19	23.85	18.85	23.53	22.59
9⅞	19.94	21.70	7.38	24.47	19.34	24.14	23.17
10	20.45	22.25	7.56	25.09	19.83	24.77	23.76
10⅛	20.97	22.81	7.75	25.72	20.33	25.38	24.36
10¼	21.49	23.38	7.95	26.36	20.84	26.01	24.96
10⅜	22.01	23.95	8.14	27.01	21.35	26.65	25.57
10½	22.55	24.53	8.34	27.67	21.86	27.28	26.19
10⅝	23.09	25.12	8.54	28.33	22.39	27.94	26.82
10¾	23.63	25.71	8.74	29.00	22.92	28.61	27.46
10⅞	24.19	26.32	8.95	29.68	23.45	29.28	28.10
11	24.75	26.92	9.15	30.36	24.00	29.96	28.75
11⅛	25.31	27.54	9.36	31.06	24.54	30.64	29.40
11¼	25.88	28.16	9.57	31.76	25.09	31.34	30.07
11⅜	26.46	28.79	9.79	32.47	25.66	32.04	30.74
11½	27.05	29.43	10.00	33.19	26.23	32.75	31.42
11⅝	27.64	30.07	10.22	33.91	26.80	33.46	32.11
11¾	28.24	30.72	10.44	34.64	27.38	34.18	32.80
11⅞	28.84	31.38	10.67	35.39	27.97	34.92	33.50
12	29.45	32.04	10.89	36.13	28.56	35.65	34.21
12⅛	30.07	32.71	11.12	36.89	29.16	36.40	34.93
12¼	30.69	33.39	11.35	37.66	29.76	37.16	35.65
12⅜	31.32	34.08	11.58	38.43	30.37	37.92	36.38
12½	31.96	34.77	11.82	39.21	30.99	38.69	37.12
12⅝	32.60	35.47	12.06	40.00	31.61	39.47	37.87

Weight of Rod or Cylinder 1 Inch Long When Cast in

Dia. in inches	Cast iron	Steel	Alumi-num	Copper	Zinc	Gun metal	Yellow brass
12¾	33.25	36.17	12.30	40.79	32.24	40.25	38.62
12⅞	33.90	36.88	12.54	41.60	32.87	41.04	39.38
13	34.56	37.60	12.78	42.41	33.51	41.84	40.15
13⅛	35.23	38.33	13.03	43.23	34.16	42.65	40.93
13¼	35.91	39.06	13.28	44.05	34.82	43.46	41.71
13⅜	36.59	39.80	13.53	44.89	35.48	44.30	42.50
13½	37.27	40.55	13.78	45.73	36.14	45.12	43.30
13⅝	37.97	41.31	14.04	46.58	36.82	45.96	44.10
13¾	38.67	42.07	14.30	47.44	37.49	46.81	44.92
13⅞	39.37	42.84	14.56	48.31	38.18	47.67	45.74
14	40.09	43.62	14.82	49.18	38.87	48.53	46.57
14⅛	40.80	44.39	15.09	50.07	39.57	49.40	47.40
14¼	41.53	45.18	15.36	50.96	40.27	50.28	48.24
14⅜	42.26	45.98	15.63	51.85	40.98	51.16	49.09
14½	43.00	46.78	15.90	52.76	41.70	52.06	49.95
14⅝	43.74	47.59	16.18	53.67	42.42	52.96	50.82
14¾	44.50	48.41	16.46	54.59	43.15	53.86	51.69
14⅞	45.25	49.23	16.74	55.52	43.88	54.78	52.57
15	46.02	50.06	17.02	56.46	44.62	55.71	53.46
15¼	47.56	51.75	17.59	58.36	46.12	57.58	55.25
15½	49.14	53.46	18.17	60.29	47.64	59.49	57.08
15¾	50.73	55.20	18.76	62.25	49.19	61.41	58.94
16	52.36	56.96	19.36	64.24	50.76	63.37	60.82
16¼	54.01	58.76	19.97	66.26	52.36	65.38	62.78
16½	55.68	60.58	20.59	68.32	54.00	67.41	64.64
16¾	57.38	62.43	21.22	70.40	55.64	69.46	66.66
17	59.11	64.30	21.86	72.52	57.31	71.55	68.66
17¼	60.86	66.21	22.51	74.67	59.01	73.68	70.70
17½	62.63	68.14	23.16	76.85	60.73	75.83	72.76
17¾	64.44	70.10	23.83	79.06	62.48	78.01	74.85
18	66.26	72.09	24.51	81.30	64.25	80.22	76.98
18¼	68.12	74.11	25.19	83.58	65.05	82.47	79.13
18½	70.00	76.15	25.89	85.88	67.87	84.74	81.31
18¾	71.90	78.22	26.59	88.22	69.72	87.05	83.53
19	73.83	80.32	27.30	90.59	71.59	89.38	85.77
19¼	75.79	82.45	28.03	92.99	73.49	91.75	88.04
19½	77.77	84.61	28.76	95.42	75.41	94.15	90.34
19¾	79.77	86.79	29.50	97.88	77.36	96.58	92.67
20	81.81	89.00	30.25	100.4	79.33	99.03	95.03

For finding weights of rods or cylinders of any length see page 113.

WEIGHT OF RODS OR CYLINDERS PER RUNNING INCH
(Continued)

	Weight of Rod or Cylinder 1 Inch Long When Cast in								Weight of Rod or Cylinder 1 Inch Long When Cast in						
Dia. in in.	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun metal	Yellow brass	Dia. in in.	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun met'l	Yel'w brass
20¼	83.87	91.24	31.02	102.9	81.32	101.7	97.42	30	184.1	200.3	68.08	225.8	178.5	222.8	213.8
20½	85.95	93.51	31.79	105.5	83.34	104.1	99.85	30¼	187.2	203.6	69.21	229.6	181.5	226.5	217.4
20¾	88.06	95.80	32.57	108.1	85.39	106.6	102.3	30½	190.3	207.0	70.36	233.4	184.5	230.3	221.0
21	90.19	98.13	33.36	110.7	87.46	109.2	104.8	30¾	193.4	210.4	71.52	237.3	187.5	234.1	224.6
21¼	92.35	100.5	34.15	113.3	89.55	111.8	107.3	31	196.6	213.8	72.69	241.1	190.6	237.9	228.3
21½	94.54	102.9	34.96	116.0	91.67	114.4	109.8	31¼	199.7	217.3	73.87	245.1	193.7	241.8	232.0
21¾	96.75	105.3	35.78	118.7	93.82	117.1	112.4	31½	202.9	220.8	75.05	249.0	196.8	245.6	235.7
22	98.99	107.7	36.61	121.5	95.98	119.8	115.0	31¾	206.2	224.3	76.25	253.0	199.9	249.6	239.5
22¼	101.2	110.2	37.45	124.2	98.18	122.5	117.6	32	209.4	227.9	77.45	257.0	203.1	253.5	243.3
22½	103.5	112.6	38.29	127.0	100.4	125.3	120.3	32¼	212.7	231.4	78.67	261.0	206.3	257.5	247.1
22¾	105.9	115.2	39.15	129.9	102.6	128.2	123.0	32½	216.0	235.0	79.89	265.1	209.4	261.5	250.9
23	108.2	117.7	40.01	132.7	104.9	130.9	125.7	32¾	219.4	238.7	81.13	269.1	212.7	265.5	254.8
23¼	110.6	120.3	40.89	135.6	107.2	133.8	128.4	33	222.7	242.3	82.37	273.3	216.0	269.6	258.7
23½	112.9	122.9	41.77	138.5	109.5	136.6	131.2	33¼	226.1	246.0	83.62	277.4	219.3	273.7	262.6
23¾	115.4	125.5	42.67	141.5	111.9	139.6	134.0	33½	229.5	249.7	84.88	281.6	222.6	277.8	266.6
24	117.8	128.2	43.57	144.5	114.2	142.6	136.9	33¾	233.0	253.5	86.15	285.8	225.9	281.0	270.6
24¼	120.3	130.9	44.48	147.5	116.6	145.5	139.7	34	236.4	257.2	87.44	290.1	229.3	286.2	274.6
24½	122.8	133.6	45.40	150.6	119.0	148.6	142.6	34¼	239.9	261.0	88.73	294.4	232.6	290.5	278.7
24¾	125.3	136.3	46.33	153.7	121.5	151.6	145.5	34½	243.4	264.8	90.03	298.7	236.1	294.7	282.7
25	127.8	139.1	47.27	156.8	124.0	154.7	148.5	34¾	247.0	268.7	91.34	303.0	239.5	299.0	286.9
25¼	130.4	141.9	48.22	160.0	126.4	157.8	151.5	35	250.5	272.6	92.65	307.4	243.0	303.3	291.0
25½	133.0	144.7	49.18	163.0	129.0	160.9	154.5	35¼	254.1	276.5	93.98	311.8	246.4	307.6	295.2
25¾	135.6	147.5	50.15	166.4	131.5	164.2	157.5	35½	257.7	280.4	95.32	316.2	249.9	312.0	299.4
26	138.3	150.4	51.13	169.6	134.1	167.3	160.6	35¾	261.4	284.4	96.67	320.7	253.5	316.4	303.6
26¼	140.9	153.3	52.12	172.9	136.7	170.6	163.7	36	265.1	288.4	98.02	325.2	257.0	320.9	307.9
26½	143.6	156.3	53.12	176.2	139.3	173.8	166.8	36¼	268.7	292.4	99.39	329.7	260.6	325.3	312.2
26¾	146.3	159.2	54.12	179.6	141.9	177.2	170.0	36½	272.5	296.4	100.8	334.3	264.2	329.8	316.5
27	149.1	162.2	55.14	183.0	144.6	180.5	173.2	36¾	276.2	300.5	102.1	338.9	267.8	334.4	320.8
27¼	151.9	165.2	56.17	186.4	147.3	183.9	176.4	37	280.0	304.6	103.5	343.5	271.5	338.9	325.2
27½	154.7	168.3	57.20	189.8	150.0	187.3	180.0	37¼	283.8	308.7	104.9	348.2	275.2	343.5	329.6
27¾	157.5	171.3	58.25	193.2	152.7	190.6	182.9	37½	287.6	312.9	106.4	352.9	278.9	348.4	334.1
28	160.3	174.4	59.30	196.7	155.5	194.1	186.3	37¾	291.4	317.1	107.8	357.6	282.6	352.8	338.5
28¼	163.2	177.6	60.36	200.3	158.3	197.3	189.6	38	295.3	321.3	109.2	362.3	286.4	357.5	343.0
28½	166.1	180.7	61.44	203.8	161.1	201.1	193.0	38¼	299.2	325.5	110.7	367.1	290.1	362.2	347.6
28¾	169.0	183.9	62.52	207.4	163.9	204.7	196.4	38½	303.1	329.8	112.1	371.9	294.0	366.5	352.1
29	172.0	187.1	63.61	211.0	166.8	208.2	199.8	38¾	307.1	334.1	113.6	376.8	297.8	371.7	356.7
29¼	175.0	190.4	64.71	214.7	169.7	211.8	203.3	39	311.1	338.4	115.0	381.7	301.6	376.6	361.4
29½	178.0	193.6	65.82	218.3	172.6	215.4	206.7	40	327.2	356.0	121.0	401.5	317.3	396.1	380.1
29¾	181.0	196.9	66.94	222.1	175.5	219.1	210.3	41	343.8	374.0	127.1	421.8	333.4	416.2	399.4

For finding weights of rods or cylinders of any length see page 113.

WEIGHT OF RODS OR CYLINDERS PER RUNNING INCH

(Concluded)

Dia. in in.	Weight of Rod or Cylinder 1 Inch Long When Cast in						
	Cast iron	Steel	Alum-inum	Cop-per	Zinc	Gun met'l	Yel. brass
42	360.8	395.5	133.4	442.6	349.8	436.7	419.1
43	378.1	411.4	139.8	464.0	366.7	457.8	439.3
44	395.9	430.8	146.4	485.8	383.9	479.3	460.0
45	414.2	450.6	153.2	508.1	401.6	501.3	481.1
46	432.7	470.8	160.0	531.0	419.6	523.9	502.7
47	451.8	491.5	167.1	554.3	438.1	546.9	524.8
48	471.2	512.7	174.3	578.1	456.9	570.4	547.4
49	491.1	534.2	181.6	602.5	476.2	593.4	570.4
50	511.3	556.3	189.1	627.3	495.8	618.9	594.0
51	531.9	578.7	196.7	652.7	515.8	644.0	618.0
52	553.0	601.7	204.5	678.5	536.2	669.4	642.4
53	574.5	625.0	212.4	704.9	557.1	695.5	667.4
54	596.4	648.8	220.5	731.7	578.3	721.9	692.8
55	618.7	673.1	228.8	759.0	599.9	748.9	718.7
56	641.4	697.8	237.2	786.9	621.9	776.4	745.0
57	664.5	722.9	245.7	815.3	644.3	804.4	771.9
58	688.0	748.5	254.4	844.1	667.1	832.9	799.2
59	711.9	774.5	263.3	873.5	690.3	861.8	827.0
60	736.3	801.0	272.3	903.4	713.9	891.3	855.2
61	761.0	827.9	281.4	933.7	737.9	921.3	884.0
62	786.2	855.3	290.7	964.6	762.3	951.7	913.2
63	811.7	883.1	300.2	995.9	787.1	982.6	942.9
64	837.7	911.4	309.8	1022	812.3	1014	973.1
65	864.1	910.1	319.6	1060	837.9	1046	1004
66	890.9	969.2	329.5	1093	863.9	1078	1035
67	918.1	998.8	339.5	1126	890.2	1111	1066
68	945.7	1029	349.7	1160	917.0	1144	1099
69	973.7	1059	360.1	1195	944.2	1179	1131
70	1002	1090	370.6	1230	971.7	1213	1164
71	1031	1122	381.3	1265	999.7	1248	1198
72	1060	1153	392.1	1301	1028	1284	1232
73	1090	1186	403.1	1337	1057	1319	1266
74	1120	1218	414.2	1374	1086	1355	1301
75	1150	1252	425.4	1411	1116	1392	1336
76	1181	1285	436.9	1449	1145	1429	1372
77	1213	1319	448.4	1488	1176	1468	1409
78	1244	1354	460.2	1527	1207	1506	1446
79	1276	1389	472.0	1566	1238	1545	1483
80	1309	1424	484.1	1606	1269	1584	1521
81	1342	1460	496.2	1646	1301	1624	1559
82	1375	1496	508.6	1687	1334	1664	1598
83	1409	1533	521.1	1729	1366	1706	1637
84	1443	1570	533.7	1771	1399	1747	1676
85	1478	1608	546.4	1813	1433	1789	1717
86	1513	1646	559.4	1856	1467	1830	1757
87	1548	1684	572.5	1899	1501	1873	1798
88	1584	1723	585.7	1943	1536	1917	1840
89	1620	1762	599.1	1988	1571	1961	1882
90	1657	1802	612.6	2033	1606	2006	1924
91	1694	1843	626.3	2078	1642	2050	1967
92	1731	1883	640.1	2124	1679	2095	2011
93	1769	1924	654.1	2170	1715	2141	2055
94	1807	1966	668.3	2217	1752	2188	2099
95	1846	2008	682.6	2265	1790	2235	2144
96	1885	2051	697.0	2313	1828	2282	2190
97	1924	2004	711.6	2361	1866	2329	2236
98	1964	2137	726.4	2410	1905	2378	2282
99	2004	2181	741.3	2459	1944	2426	2329
100	2045	2225	756.3	2509	1983	2477	2376
101	2086	2270	771.5	2560	2023	2526	2424
102	2128	2315	786.9	2611	2063	2576	2472
103	2170	2361	802.4	2662	2104	2627	2521
104	2212	2407	818.1	2714	2145	2677	2570
105	2255	2453	833.9	2767	2186	2723	2619
106	2298	2500	849.8	2819	2228	2780	2669
107	2342	2547	866.0	2873	2270	2834	2720

The weight per running inch for diameter with a fraction such as 82⅜ can be found by interpolation as follows:

Add the product of the fractional part of the diameter multiplied by the difference between the weights in table corresponding to the next even inches above and below the given diameter to the weight corresponding to the next even inch under, the result being the required weight per running inch: Thus for cast iron ring 82⅜ diameter, from table 83 = 1409 82 = 1375 1409—1375 = 34, 34×⅜ = 13; 1375 + 13 = 1388, weight per running inch for 82⅜ diameter.

For finding weights of rods or cylinders of any length, see page 113.

PATTERN SIZE AND WEIGHT OF CAST-IRON PIPE

5/16 TO 1 1/32 INCHES THICK

Thickness, inches		$\frac{5}{16}$	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{13}{32}$	$\frac{7}{16}$	$\frac{15}{32}$	$\frac{1}{2}$	$\frac{17}{32}$	$\frac{9}{16}$	$\frac{19}{32}$	$\frac{5}{8}$	$\frac{21}{32}$	$\frac{11}{16}$	$\frac{23}{32}$	$\frac{3}{4}$	$\frac{25}{32}$	$\frac{13}{16}$	$\frac{27}{32}$	$\frac{7}{8}$	$\frac{29}{32}$	$\frac{15}{16}$	$\frac{31}{32}$	1	$1\frac{1}{32}$
3-inch Pipe	Pattern size, inches	$3\frac{23}{32}$	$3\frac{25}{32}$	$3\frac{27}{32}$	$3\frac{29}{32}$	$3\frac{31}{32}$	$4\frac{1}{32}$	$4\frac{3}{32}$	$4\frac{5}{32}$	$4\frac{7}{32}$	$4\frac{9}{32}$	$4\frac{11}{32}$	$4\frac{13}{32}$	$4\frac{15}{32}$	$4\frac{17}{32}$	$4\frac{19}{32}$	$4\frac{21}{32}$	$4\frac{23}{32}$	$4\frac{25}{32}$	$4\frac{27}{32}$	$4\frac{29}{32}$	$4\frac{31}{32}$	$5\frac{1}{32}$	$5\frac{3}{32}$	....
	Weight, pounds.....	132	147	162	177	193	208	224	240	256	272	288	306	324	342	360	378	396	415	434	453	472	491	511	....
4-inch Pipe	Pattern size, inches	$4\frac{23}{32}$	$4\frac{25}{32}$	$4\frac{27}{32}$	$4\frac{29}{32}$	$4\frac{31}{32}$	$5\frac{1}{32}$	$5\frac{3}{32}$	$5\frac{5}{32}$	$5\frac{7}{32}$	$5\frac{9}{32}$	$5\frac{11}{32}$	$5\frac{13}{32}$	$5\frac{15}{32}$	$5\frac{17}{32}$	$5\frac{19}{32}$	$5\frac{21}{32}$	$5\frac{23}{32}$	$5\frac{25}{32}$	$5\frac{27}{32}$	$5\frac{29}{32}$	$5\frac{31}{32}$	$6\frac{1}{32}$	$6\frac{3}{32}$	$6\frac{5}{32}$
	Weight, pounds.....	172	191	210	229	248	268	288	308	328	349	370	390	412	434	456	478	500	522	545	568	591	615	639	663
5-inch Pipe	Pattern size, inches	$5\frac{23}{32}$	$5\frac{25}{32}$	$5\frac{27}{32}$	$5\frac{29}{32}$	$5\frac{31}{32}$	$6\frac{1}{32}$	$6\frac{3}{32}$	$6\frac{5}{32}$	$6\frac{7}{32}$	$6\frac{9}{32}$	$6\frac{11}{32}$	$6\frac{13}{32}$	$6\frac{15}{32}$	$6\frac{17}{32}$	$6\frac{19}{32}$	$6\frac{21}{32}$	$6\frac{23}{32}$	$6\frac{25}{32}$	$6\frac{27}{32}$	$6\frac{29}{32}$	$6\frac{31}{32}$	$7\frac{1}{32}$	$7\frac{3}{32}$	$7\frac{5}{32}$
	Weight, pounds.....	212	235	258	281	304	328	351	376	400	425	450	474	500	525	551	577	604	631	657	684	711	734	767	795
6-inch Pipe	Pattern size, inches	$6\frac{3}{4}$	$6\frac{13}{16}$	$6\frac{7}{8}$	$6\frac{15}{16}$	7	$7\frac{1}{16}$	$7\frac{1}{8}$	$7\frac{3}{16}$	$7\frac{1}{4}$	$7\frac{5}{16}$	$7\frac{3}{8}$	$7\frac{7}{16}$	$7\frac{1}{2}$	$7\frac{9}{16}$	$7\frac{5}{8}$	$7\frac{11}{16}$	$7\frac{3}{4}$	$7\frac{13}{16}$	$7\frac{7}{8}$	$7\frac{15}{16}$	8	$8\frac{1}{16}$	$8\frac{1}{8}$	$8\frac{3}{16}$
	Weight, pounds.....	253	279	306	333	360	389	416	444	472	500	529	558	587	617	647	677	708	738	769	802	837	863	895	932
7-inch Pipe	Pattern size, inches	$7\frac{3}{4}$	$7\frac{13}{16}$	$7\frac{7}{8}$	$7\frac{15}{16}$	8	$8\frac{1}{16}$	$8\frac{1}{8}$	$8\frac{3}{16}$	$8\frac{1}{4}$	$8\frac{5}{16}$	$8\frac{3}{8}$	$8\frac{7}{16}$	$8\frac{1}{2}$	$8\frac{9}{16}$	$8\frac{5}{8}$	$8\frac{11}{16}$	$8\frac{3}{4}$	$8\frac{13}{16}$	$8\frac{7}{8}$	$8\frac{15}{16}$	9	$9\frac{1}{16}$	$9\frac{1}{8}$	$9\frac{3}{16}$
	Weight, pounds.....	292	323	354	385	416	448	479	513	545	577	610	643	676	709	743	777	811	846	880	916	951	987	1023	1059
8-inch Pipe	Pattern size, inches	$8\frac{3}{4}$	$8\frac{13}{16}$	$8\frac{7}{8}$	$8\frac{15}{16}$	9	$9\frac{1}{16}$	$9\frac{1}{8}$	$9\frac{3}{16}$	$9\frac{1}{4}$	$9\frac{5}{16}$	$9\frac{3}{8}$	$9\frac{7}{16}$	$9\frac{1}{2}$	$9\frac{9}{16}$	$9\frac{5}{8}$	$9\frac{11}{16}$	$9\frac{3}{4}$	$9\frac{13}{16}$	$9\frac{7}{8}$	$9\frac{15}{16}$	10	$10\frac{1}{16}$	$10\frac{1}{8}$	$10\frac{3}{16}$
	Weight, pounds.....	332	367	401	435	471	507	543	579	616	652	689	726	765	801	839	877	916	954	993	1032	1071	1111	1151	1189
9-inch Pipe	Pattern size, inches	$9\frac{13}{16}$	$9\frac{7}{8}$	$9\frac{15}{16}$	10	$10\frac{1}{16}$	$10\frac{1}{8}$	$10\frac{3}{16}$	$10\frac{1}{4}$	$10\frac{5}{16}$	$10\frac{3}{8}$	$10\frac{7}{16}$	$10\frac{1}{2}$	$10\frac{9}{16}$	$10\frac{5}{8}$	$10\frac{11}{16}$	$10\frac{3}{4}$	$10\frac{13}{16}$	$10\frac{7}{8}$	$10\frac{15}{16}$	11	$11\frac{1}{16}$	$11\frac{1}{8}$	$11\frac{3}{16}$	$11\frac{1}{4}$
	Weight, pounds.....	371	411	449	488	528	567	607	648	688	728	769	810	851	893	935	977	1019	1062	1105	1148	1191	1234	1278	1322
10-inch Pipe	Pattern size, inches	$10\frac{13}{16}$	$10\frac{7}{8}$	$10\frac{15}{16}$	11	$11\frac{1}{16}$	$11\frac{1}{8}$	$11\frac{3}{16}$	$11\frac{1}{4}$	$11\frac{5}{16}$	$11\frac{3}{8}$	$11\frac{7}{16}$	$11\frac{1}{2}$	$11\frac{9}{16}$	$11\frac{5}{8}$	$11\frac{11}{16}$	$11\frac{3}{4}$	$11\frac{13}{16}$	$11\frac{7}{8}$	$11\frac{15}{16}$	12	$12\frac{1}{16}$	$12\frac{1}{8}$	$12\frac{3}{16}$	$12\frac{1}{4}$
	Weight, pounds....	412	455	497	540	584	627	671	715	759	804	849	893	939	985	1032	1077	1123	1170	1216	1263	1311	1358	1406	1454
12-inch Pipe	Pattern size, inches	....	$12\frac{29}{32}$	$12\frac{31}{32}$	$13\frac{1}{32}$	$13\frac{3}{32}$	$13\frac{5}{32}$	$13\frac{7}{32}$	$13\frac{9}{32}$	$13\frac{11}{32}$	$13\frac{13}{32}$	$13\frac{15}{32}$	$13\frac{17}{32}$	$13\frac{19}{32}$	$13\frac{21}{32}$	$13\frac{23}{32}$	$13\frac{25}{32}$	$13\frac{27}{32}$	$13\frac{29}{32}$	$13\frac{31}{32}$	$14\frac{1}{32}$	$14\frac{3}{32}$	$14\frac{5}{32}$	$14\frac{7}{32}$	$14\frac{9}{32}$
	Weight, pounds....	....	542	594	644	695	747	799	851	903	956	1008	1062	1115	1168	1222	1277	1331	1385	1440	1495	1550	1606	1662	1718
14-inch Pipe	Pattern size, inches	....	....	15	$15\frac{1}{16}$	$15\frac{1}{8}$	$15\frac{3}{16}$	$15\frac{1}{4}$	$15\frac{5}{16}$	$15\frac{3}{8}$	$15\frac{7}{16}$	$15\frac{1}{2}$	$15\frac{9}{16}$	$15\frac{5}{8}$	$15\frac{11}{16}$	$15\frac{3}{4}$	$15\frac{13}{16}$	$15\frac{7}{8}$	$15\frac{15}{16}$	16	$16\frac{1}{16}$	$16\frac{1}{8}$	$16\frac{3}{16}$	$16\frac{1}{4}$	$16\frac{5}{16}$
	Weight, pounds....	....	....	689	748	807	867	927	987	1047	1108	1169	1230	1291	1352	1414	1476	1538	1601	1664	1727	1790	1853	1917	1982
16-inch Pipe	Pattern size, inches	....	....	....	$17\frac{1}{16}$	$17\frac{1}{8}$	$17\frac{3}{16}$	$17\frac{1}{4}$	$17\frac{5}{16}$	$17\frac{3}{8}$	$17\frac{7}{16}$	$17\frac{1}{2}$	$17\frac{9}{16}$	$17\frac{5}{8}$	$17\frac{11}{16}$	$17\frac{3}{4}$	$17\frac{13}{16}$	$17\frac{7}{8}$	$17\frac{15}{16}$	18	$18\frac{1}{16}$	$18\frac{1}{8}$	$18\frac{3}{16}$	$18\frac{1}{4}$	$18\frac{5}{16}$
	Weight, pounds....	....	....	....	852	919	987	1055	1123	1191	1259	1329	1397	1466	1536	1606	1676	1746	1817	1888	1958	2030	2101	2173	2245
18-inch Pipe	Pattern size, inches	....	....	....	....	$19\frac{1}{8}$	$19\frac{3}{16}$	$19\frac{1}{4}$	$19\frac{5}{16}$	$19\frac{3}{8}$	$19\frac{7}{16}$	$19\frac{1}{2}$	$19\frac{9}{16}$	$19\frac{5}{8}$	$19\frac{11}{16}$	$19\frac{3}{4}$	$19\frac{13}{16}$	$19\frac{7}{8}$	$19\frac{15}{16}$	20	$20\frac{1}{16}$	$20\frac{1}{8}$	$20\frac{3}{16}$	$20\frac{1}{4}$	$20\frac{5}{16}$
	Weight, pounds....	....	....	....	....	1031	1106	1182	1258	1335	1411	1488	1562	1642	1720	1798	1876	1954	2032	2111	2190	2269	2349	2429	2509
20-inch Pipe	Pattern size, inches	....	....	....	....	....	$21\frac{1}{4}$	$21\frac{5}{16}$	$21\frac{3}{8}$	$21\frac{7}{16}$	$21\frac{1}{2}$	$21\frac{9}{16}$	$21\frac{5}{8}$	$21\frac{11}{16}$	$21\frac{3}{4}$	$21\frac{13}{16}$	$21\frac{7}{8}$	$21\frac{15}{16}$	22	$22\frac{1}{16}$	$22\frac{1}{8}$	$22\frac{3}{16}$	$22\frac{1}{4}$	$22\frac{5}{16}$	$22\frac{3}{8}$
	Weight, pounds....	....	....	....	....	....	1226	1310	1394	1479	1553	1648	1732	1818	1903	1987	2075	2160	2246	2333	2420	2508	2596	2684	2778
22-inch Pipe	Pattern size, inches	....	....	....	....	....	....	$23\frac{5}{16}$	$23\frac{3}{8}$	$23\frac{7}{16}$	$23\frac{1}{2}$	$23\frac{9}{16}$	$23\frac{5}{8}$	$23\frac{11}{16}$	$23\frac{3}{4}$	$23\frac{13}{16}$	$23\frac{7}{8}$	$23\frac{15}{16}$	24	$24\frac{1}{16}$	$24\frac{1}{8}$	$24\frac{3}{16}$	$24\frac{1}{4}$	$24\frac{5}{16}$	$24\frac{3}{8}$
	Weight, pounds....	....	....	....	....	....	....	1437	1529	1622	1715	1808	1901	1994	2088	2182	2276	2370	2464	2558	2653	2748	2844	2940	3038
24-inch Pipe	Pattern size, inches	....	....	....	....	....	....	....	$25\frac{3}{8}$	$25\frac{7}{16}$	$25\frac{1}{2}$	$25\frac{9}{16}$	$25\frac{5}{8}$	$25\frac{11}{16}$	$25\frac{3}{4}$	$25\frac{13}{16}$	$25\frac{7}{8}$	$25\frac{15}{16}$	26	$26\frac{1}{16}$	$26\frac{1}{8}$	$26\frac{3}{16}$	$26\frac{1}{4}$	$26\frac{5}{16}$	$26\frac{3}{8}$
	Weight, pounds....	....	....	....	....	....	....	....	1666	1766	1867	1968	2069	2171	2271	2373	2475	2577	2679	2782	2883	2989	3092	3195	3299
30-inch Pipe	Pattern size, inches	....	....	....	....	....	....	....	....	$31\frac{1}{2}$	$31\frac{9}{16}$	$31\frac{5}{8}$	$31\frac{11}{16}$	$31\frac{3}{4}$	$31\frac{13}{16}$	$31\frac{7}{8}$	$31\frac{15}{16}$	32	$32\frac{1}{16}$	$32\frac{1}{8}$	$32\frac{3}{16}$	$32\frac{1}{4}$	$32\frac{5}{16}$	$32\frac{3}{8}$	$32\frac{7}{16}$
	Weight, pounds....	....	....	....	....	....	....	....	....	2198	2322	2447	2572	2697	2823	2948	3075	3201	3327	3453	3580	3707	3834	3962	4090
36-inch Pipe	Pattern size, inches	....	....	....	....	....	....	....	....	....	....	....	$37\frac{3}{4}$	$37\frac{13}{16}$	$37\frac{7}{8}$	$37\frac{15}{16}$	38	$38\frac{1}{16}$	$38\frac{1}{8}$	$38\frac{3}{16}$	$38\frac{1}{4}$	$38\frac{5}{32}$	$38\frac{3}{8}$	$38\frac{7}{16}$	$38\frac{1}{2}$
	Weight, pounds....	....	....	....	....	....	....	....	....	....	....	....	3072	3222	3372	3523	3674	3825	3976	4122	4279	4431	4583	4735	4887

PATTERN SIZE AND WEIGHT OF CAST-IRON PIPE

(Continued)

1 1/16 TO 1 3/4 INCHES THICK

Thickness, inches		1 1/16	1 3/32	1 1/8	1 5/32	1 3/16	1 7/32	1 1/4	1 9/32	1 5/16	1 11/32	1 3/8	1 13/32	1 7/16	1 15/32	1 1/2	1 17/32	1 9/16	1 19/32	1 5/8	1 21/32	1 11/16	1 23/32	1 3/4
3-inch	Pattern size, inches	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
4-inch	Pattern size, inches	6 7/32	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	687	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
5-inch	Pattern size, inches	7 7/32	7 9/32	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	823	851	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
6-inch	Pattern size, inches	8 1/4	8 5/16	8 3/8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	959	992	1025	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7-inch	Pattern size, inches	9 1/4	9 5/16	9 3/8	9 7/16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	1095	1132	1168	1206	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
8-inch	Pattern size, inches	10 1/4	10 5/16	10 3/8	10 7/16	10 1/2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	1230	1271	1312	1353	1395	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9-inch	Pattern size, inches	11 5/16	11 3/8	11 7/16	11 1/2	11 9/16	11 5/8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	1366	1411	1456	1501	1547	1593	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
10-inch	Pattern size, inches	12 5/16	12 3/8	12 7/16	12 1/2	12 9/16	12 5/8	12 11/16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	1503	1551	1600	1649	1698	1747	1797	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12-inch	Pattern size, inches	14 11/32	14 13/32	14 15/32	14 17/32	14 19/32	14 21/32	14 23/32	14 25/32	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	1774	1831	1887	1944	2001	2059	2117	2175	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
14-inch	Pattern size, inches	16 3/8	16 7/16	16 1/2	16 9/16	16 5/8	16 11/16	16 3/4	16 13/16	16 7/8	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	2046	2110	2175	2240	2305	2371	2437	2502	2569	....	....	....	....	....	....	....	....	....	....	....	....	....	....
16-inch	Pattern size, inches	18 3/8	18 7/16	18 1/2	18 9/16	18 5/8	18 11/16	18 3/4	18 13/16	18 7/8	18 15/16	19	....	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	2317	2380	2463	2536	2609	2683	2757	2831	2905	2979	3054	....	....	....	....	....	....	....	....	....	....	....	....
18-inch	Pattern size, inches	20 3/8	20 7/16	20 1/2	20 9/16	20 5/8	20 11/16	20 3/4	20 13/16	20 7/8	20 15/16	21	21 1/16	....	....	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	2589	2669	2750	2831	2913	2995	3076	3158	3240	3322	3405	3488	....	....	....	....	....	....	....	....	....	....	....
20-inch	Pattern size, inches	22 7/16	22 1/2	22 9/16	22 5/8	22 11/16	22 3/4	22 13/16	22 7/8	22 15/16	23	23 1/16	23 1/8	23 3/16	23 1/4	....	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	2861	2949	3038	3127	3216	3306	3396	3486	3576	3666	3757	3848	3939	4030	....	....	....	....	....	....	....	....	....
22-inch	Pattern size, inches	24 7/16	24 1/2	24 9/16	24 5/8	24 11/16	24 3/4	24 13/16	24 7/8	24 15/16	25	25 1/16	25 1/8	25 3/16	25 1/4	25 5/16	....	....	....	....	....	....	....	....
Pipe	Weight, pounds....	3132	3229	3326	3423	3520	3617	3715	3813	3912	4010	4109	4208	4307	4406	4506	....	....	....	....	....	....	....	....
24-inch	Pattern size, inches	26 7/16	26 1/2	26 9/16	26 5/8	26 11/16	26 3/4	26 13/16	26 7/8	26 15/16	27	27 1/16	27 1/8	27 3/16	27 1/4	27 5/16	27 3/8	27 7/16	....	....	....	....	....	....
Pipe	Weight, pounds....	3403	3507	3612	3717	3822	3928	4034	4140	4246	4352	4459	4566	4674	4782	4890	4998	5106	....	....	....	....	....	....
30-inch	Pattern size, inches	32 1/2	32 9/16	32 5/8	32 11/16	32 3/4	32 13/16	32 7/8	32 15/16	33	33 1/16	33 1/8	33 3/16	33 1/4	33 5/16	33 3/8	33 7/16	33 1/2	33 9/16	33 5/8	....	....	....	....
Pipe	Weight, pounds....	4218	4347	4476	4605	4734	4863	4993	5123	5253	5384	5515	5646	5777	5908	6040	6172	6304	6436	6569	....	....	....	....
36-inch	Pattern size, inches	38 9/16	38 5/8	38 11/16	38 3/4	38 13/16	38 7/8	38 15/16	39	39 1/16	39 1/8	39 3/16	39 1/4	39 5/16	39 3/8	39 7/16	39 1/2	39 9/16	39 5/8	39 11/16	39 3/4	39 13/16	39 7/8	39 15/16
Pipe	Weight, pounds....	5040	5193	5346	5499	5652	5806	5960	6114	6268	6428	6576	6731	6886	7041	7196	7351	7507	7663	7820	7985	8141	8298	8455

PATTERN SIZE AND WEIGHT OF CAST-IRON PIPE

(Concluded)

3/4 TO 2 9/32 INCHES THICK

Thickness, inches		3/4	25/32	13/16	27/32	7/8	29/32	15/16	31/32	1	1 1/32	1 1/16	1 3/32	1 1/8	1 5/32	1 3/16	1 7/32	1 1/4	1 9/32	1 5/16	1 11/32
40-inch Pipe	Pattern size, inches	42	42 1/16	42 1/8	42 3/16	42 1/4	42 5/16	42 3/8	42 7/16	42 1/2	42 9/16	42 5/8	42 11/16	42 3/4	42 13/16	42 7/8	42 15/16	43	43 1/16	43 1/8	43 3/16
	Weights, pounds...	3910	4075	4240	4405	4571	4737	4903	5070	5237	5404	5572	5740	5908	6077	6246	6415	6585	6755	6925	7096
42-inch Pipe	Pattern size, inches	....	....	44 1/8	44 3/16	44 1/4	44 5/16	44 3/8	44 7/16	44 1/2	44 9/16	44 5/8	44 11/16	44 3/4	44 13/16	44 7/8	44 15/16	45	45 1/16	45 1/8	45 3/16
	Weights, pounds...	....	....	4440	4615	4790	4965	5140	5316	5492	5668	5844	6021	6198	6375	6552	6730	6908	7086	7264	7443
48-inch Pipe	Pattern size, inches	....	....	....	....	....	....	50 7/16	50 1/2	50 9/16	50 5/8	50 11/16	50 3/4	50 13/16	50 7/8	50 15/16	51	51 1/16	51 1/8	51 3/16	51 1/4
	Weight, pounds....	....	....	....	....	....	....	5969	6068	6267	6467	6667	6867	7067	7268	7469	7670	7871	8073	8275	8477
60-inch Pipe	Pattern size, inches	....	....	....	....	....	....	....	....	....	....	62 7/8	62 15/16	63	63 1/16	63 1/8	63 3/16	63 1/4	63 5/16	63 3/8	63 7/16
	Weight, pounds....	....	....	....	....	....	....	....	....	....	....	8282	8532	8782	9032	9282	9532	9782	10032	10283	10534

Thickness, inches		1 3/8	1 13/32	1 7/16	1 15/32	1 1/2	1 17/32	1 9/16	1 19/32	1 5/8	1 21/32	1 11/16	1 23/32	1 3/4	1 25/32	1 13/16
40-inch Pipe	Pattern size, inches	43 1/4	43 5/16	43 3/8	43 7/16	43 1/2	43 9/16	43 5/8	43 11/16	43 3/4	43 13/16	43 7/8	43 15/16	44	44 1/16	44 1/8
	Weight, pounds....	7267	7438	7610	7782	7954	8127	8300	8473	8647	8821	8995	9170	9345	9520	9688
42-inch Pipe	Pattern size, inches	45 1/4	45 5/16	45 3/8	45 7/16	45 1/2	45 9/16	45 5/8	45 11/16	45 3/4	45 13/16	45 7/8	45 15/16	46	46 1/16	46 1/8
	Weight, pounds....	7622	7801	7980	8160	8340	8520	8700	8881	9062	9243	9424	9606	9788	9970	10152
48-inch Pipe	Pattern size, inches	51 5/16	51 3/8	51 7/16	51 1/2	51 9/16	51 5/8	51 11/16	51 3/4	51 13/16	51 7/8	51 15/16	52	52 1/16	52 1/8	52 3/16
	Weight, pounds....	8679	8882	9083	9288	9491	9695	9899	10103	10307	10512	10717	10922	11127	11333	11539
60-inch Pipe	Pattern size, inches	63 1/2	63 9/16	63 5/8	63 11/16	63 3/4	63 13/16	63 7/8	63 15/16	64	64 1/16	64 1/8	64 3/16	64 1/4	64 5/16	64 3/8
	Weight, pounds....	10785	11086	11337	11588	11839	12091	12343	12545	12847	13099	13357	13603	13856	14109	14362

Thickness, inches		1 27/32	1 7/8	1 29/32	1 15/16	1 31/32	2	2 1/32	2 1/16	2 3/32	2 1/8	2 5/32	2 3/16	2 7/32	2 1/4	2 9/32
40-inch Pipe	Pattern size, inches	44 3/16	44 1/4	....	....	....	....	....	....	....	....	....	....	....	....	....
	Weight, pounds....	9862	10048	....	....	....	....	....	....	....	....	....	....	....	....	....
42-inch Pipe	Pattern size, inches	46 3/16	46 1/4	46 5/16	46 3/8	....	....	....	....	....	....	....	....	....	....	....
	Weight, pounds....	10335	10518	10700	10885	....	....	....	....	....	....	....	....	....	....	....
48-inch Pipe	Pattern size, inches	52 1/4	52 5/16	52 3/8	52 7/16	52 1/2	52 9/16	52 5/8	52 11/16	52 3/4	52 13/16	....	....	....	....	....
	Weight, pounds....	11745	11951	12158	12365	12572	12779	12987	13195	13443	13611	....	....	....	....	....
60-inch Pipe	Pattern size, inches	64 7/16	64 1/2	64 9/16	64 5/8	64 11/16	64 3/4	64 13/16	64 7/8	64 15/16	65	65 1/16	65 1/8	65 3/16	65 1/4	65 5/16
	Weight, pounds....	14615	14868	15121	15374	15628	15882	16136	16390	16644	16898	17152	17407	17662	17917	18172

FORMULAS FOR WEIGHTS

WEIGHT OF CASTINGS DETERMINED FROM WEIGHT OF PATTERNS

A pattern weighing one pound made of	Will weigh when cast in— Cast iron, pounds	Zinc, pounds	Copper, pounds	Yellow brass, pounds	Gun metal, pounds	Aluminum, pounds	Lead, pounds
Mahogany, Nassau	10.7	10.4	12.8	12.2	12.5	....	....
Mahogany, Honduras	12.9	12.7	15.3	14.6	15.0	....	....
Mahogany, Spanish	8.5	8.2	10.1	9.7	9.9	....	....
Pine, red	12.5	12.1	14.9	14.2	14.6	....	....
Pine, White	16.7	16.1	19.8	19.0	19.5	5.0	22.0
Pine, yellow	14.1	13.6	16.7	16.0	16.5	....	....
Oak	9.0	8.6	10.4	10.4	10.9	....	....

WEIGHT OF A SQUARE FOOT OF CAST IRON

Thickness, in inches	Weight, in pounds	Thickness, in inches	Weight, in pounds	Thickness, in inches	Weight, in pounds	Thickness, in inches	Weight, in pounds
1/4	9.37	3/4	28.12	1 1/4	46.87	1 3/4	65.62
3/8	14.06	7/8	32.81	1 3/8	51.56	1 7/8	70.31
1/2	18.75	1	37.50	1 1/2	56.25	2	75.00
5/8	23.43	1 1/8	42.18	1 5/8	60.93	...	.....

SECTION III

REFERENCES FOR PATTERNMAKERS

BOARD FEET IN PATTERN LUMBER

The accompanying table, which gives the number of board-feet in planks of various sizes, will be found of value to patternmakers and others in calculating the cost of lumber for patterns and flasks. The size of the pieces is given at the left and their length in the various columns across the top of the table.

Length in Feet

Size.	4	5	6	7	8	9	10	11	12	13	14	15	16
					Feet Board Measure								
1 x 1	0.33	0.41	0.5	0.58	0.66	0.75	0.83	0.91	1.00	1.08	1.16	1.25	1.33
1 x 2	0.66	0.82	1.0	1.16	1.32	1.50	1.66	1.82	2.00	2.16	2.32	2.50	2.66
1 x 3	1.00	1.25	1.5	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
1 x 4	1.33	1.66	2.0	2.33	2.66	3.00	3.33	3.66	4.00	4.33	4.66	5.00	5.33
1 x 5	1.66	2.08	2.5	2.91	3.33	3.75	4.16	4.58	5.00	5.41	5.83	6.25	6.66
1 x 6	2.00	2.50	3.0	3.50	4.00	4.50	5.00	5.50	6.00	6.60	7.00	7.50	8.00
1 x 7	2.33	2.91	3.5	4.08	4.66	5.25	5.81	6.37	7.00	7.57	8.16	8.75	9.33
1 x 8	2.66	3.33	4.0	4.66	5.33	6.00	6.66	7.33	8.00	8.66	9.33	10.00	10.66
1 x 9	3.00	3.75	4.5	5.25	6.00	6.75	7.50	8.25	9.00	9.75	10.50	11.25	12.00
1 x 10	3.33	4.16	5.0	5.33	6.66	7.50	8.13	9.16	10.00	10.82	11.66	12.50	13.33
1 x 11	3.66	4.58	5.5	6.11	7.33	8.25	9.16	10.08	11.00	11.90	12.82	13.75	14.66
1 x 12	4.00	5.00	6.0	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00

Length in Feet

Size	4	5	6	7	8	9	10	11	12	13	14	15	16
					Feet Board Measure								
1¼ x 1	0.41	0.52	0.62	0.73	0.83	0.93	1.04	1.14	1.25	1.35	1.45	1.56	1.66
1¼ x 2	0.83	1.04	1.25	1.45	1.66	1.87	2.08	2.28	2.50	2.70	2.91	3.12	3.33
1¼ x 3	1.24	1.56	1.87	2.18	2.50	2.81	3.12	3.43	3.75	4.05	4.37	4.68	5.00
1¼ x 4	1.66	2.08	2.50	2.91	3.32	3.75	4.16	4.57	5.00	5.41	5.82	6.25	6.66
1¼ x 5	2.08	2.60	3.12	3.64	4.16	4.63	5.20	5.72	6.25	6.76	7.28	7.81	8.32
1¼ x 6	2.50	3.12	3.75	4.37	5.00	5.62	6.25	6.87	7.50	8.10	8.75	9.37	10.00
1¼ x 7	2.91	3.64	4.38	5.10	5.83	6.56	7.29	8.01	8.75	9.47	10.20	10.93	11.66
1¼ x 8	3.32	4.16	5.00	5.82	6.65	7.50	8.32	9.15	10.00	10.82	11.66	12.50	13.32
1¼ x 9	3.75	4.66	5.62	6.56	7.50	8.43	9.37	10.29	11.25	12.18	13.12	14.05	15.00
1¼ x 10	4.16	5.20	6.25	7.27	8.33	9.57	10.30	11.54	12.50	13.52	14.55	15.62	16.64
1¼ x 11	4.58	5.72	6.87	8.01	9.17	10.31	11.45	12.60	13.75	14.88	16.03	17.18	18.35
1¼ x 12	5.00	6.25	7.50	8.75	10.00	11.25	12.50	12.75	15.00	16.25	17.50	18.75	20.00

BOARD FEET IN PATTERN LUMBER
(*Continued*)

A board foot contains 144 cubic inches of lumber. That is, a plank 12 inches square and 1 inch thick contains 1 board foot; if it were 2 inches thick, it would contain 2 board feet. However, in selling lumber, dealers always figure boards *less than* 1 *inch* thick as if they were inch boards.

	Length in Feet												
Size.	4	5	6	7	8	9	10	11	12	13	14	15	16
	Feet Board Measure												
1½ x 1	0.5	0.61	0.75	0.87	1.0	1.12	1.33	1.36	1.5	1.62	1.74	1.87	2.0
1½ x 2	1.0	1.23	1.50	1.74	2.0	2.25	2.46	2.73	3.0	3.24	3.48	3.75	4.0
1½ x 3	1.5	1.84	2.25	2.61	3.0	3.37	3.75	4.13	4.5	4.86	4.72	5.62	6.0
1½ x 4	2.0	2.49	3.00	3.49	4.0	4.50	4.99	5.49	6.0	6.49	6.99	7.50	8.0
1½ x 5	2.5	3.09	3.75	4.36	5.0	5.62	6.18	6.75	7.5	8.11	8.73	9.37	10.0
1½ x 6	3.0	3.75	4.50	5.25	6.0	6.75	7.50	8.25	9.0	9.75	10.50	11.25	12.0
1½ x 7	3.5	4.36	5.25	6.12	7.0	7.87	8.72	9.61	10.5	11.35	12.24	13.12	14.0
1½ x 8	4.0	5.00	6.00	7.00	8.0	9.00	10.00	11.00	12.0	13.00	14.00	15.00	16.0
1½ x 9	4.5	5.43	6.75	7.87	9.0	10.12	11.25	12.37	13.5	14.62	15.74	16.87	18.0
1½ x 10	5.0	6.24	7.50	8.73	10.0	11.25	12.49	13.74	15.0	16.23	17.49	18.75	20.0
1½ x 11	5.5	6.87	8.25	9.61	11.0	12.37	13.74	15.12	16.5	17.85	19.23	20.62	22.0
1½ x 12	6.0	7.50	9.00	10.50	12.0	13.50	15.00	16.50	18.0	19.50	21.00	22.50	24.0

	Length in Feet												
Size.	4	5	6	7	8	9	10	11	12	13	14	15	16
	Feet Board Measure												
2 x 1	0.66	0.32	1.0	1.16	1.32	1.50	1.66	1.82	2.0	2.16	2.32	2.5	2.66
2 x 2	1.33	1.64	2.0	2.33	2.64	3.00	3.33	3.64	4.0	4.33	4.64	5.0	5.33
2 x 3	2.00	2.50	3.0	3.50	4.00	4.50	5.00	5.50	6.0	6.50	7.00	7.5	8.00
2 x 4	2.66	3.33	4.0	4.66	5.33	6.00	6.66	7.33	8.0	8.66	9.33	10.0	10.66
2 x 5	3.33	4.16	5.0	5.82	6.66	7.50	8.33	9.16	10.0	10.82	11.66	12.5	13.33
2 x 6	4.00	5.00	6.0	7.00	8.00	9.00	10.00	11.00	12.0	13.00	14.00	15.0	16.00
2 x 7	4.66	5.82	7.0	8.16	9.33	10.50	11.62	12.74	14.0	15.14	16.33	17.5	18.66
2 x 8	5.33	6.66	8.0	9.33	10.66	12.00	13.33	14.66	16.0	17.33	18.66	20.0	21.33
2 x 9	6.00	7.50	9.0	10.50	12.00	13.50	15.00	16.50	18.0	19.50	21.00	22.5	24.00
2 x 10	6.66	8.33	10.0	11.66	13.33	15.00	16.66	18.33	20.0	21.64	23.33	25.0	26.66
2 x 11	7.33	9.16	11.0	12.82	14.66	16.50	18.33	20.16	22.0	23.80	25.64	27.5	29.33
2 x 12	8.00	10.00	12.0	14.00	16.00	18.00	20.00	22.00	24.0	26.00	28.00	30.0	32.00

BOARD FEET IN PATTERN LUMBER

(Continued)

The seven tables published on pages 122 to 125, inclusive, cover a complete range of sizes of lumber ordinarily used in making wood patterns. The first table on page 122 covers boards 1 inch thick, ranging from 1 to 12 inches in width and from 4 to 16 feet in length, the widths advancing by single inches and the lengths by feet. The second table on the same page covers boards 1¼ inches thick, also ranging in width and length from 1 to 12 inches and from 4 to 16 feet. In a similar manner, the subsequent tables cover 1½-inch, 2-inch, 2½-inch, 3-inch and 4-inch planks.

The number of board feet in planks of odd length, not given in the table, may be found by simple interpolation. For instance, to find the board feet in a plank 1½ inches thick, 5 inches wide and 10 feet 3 inches long, we first turn to the 1½-inch table on page 123. On the line opposite 1½x5, under 10 feet, we find 6.18 board feet and under 11 feet, 6.75 board feet. The difference is 0.57 board foot. Now 10 feet 3 inches is equivalent to 10¼ feet. Therefore, divide 0.57 by 4 and add the product, 0.142, to 6.18, giving 6.322 board feet in a plank 1½x5x10¼.

If neither the width nor the length is given exactly in the table, a double interpolation is necessary; and if extreme accuracy is desired, a triple interpolation may be required if the exact thickness is not in the table.

	Length in Feet												
Size.	4	5	6	7	8	9	10	11	12	13	14	15	16
	Feet Board Measure												
2½ x 1	0.82	1.08	1.25	1.50	1.66	1.88	2.08	2.25	2.5	2.75	2.88	3.16	3.33
2½ x 2	1.66	2.03	2.50	2.88	3.33	3.75	4.16	4.56	5.0	5.40	5.80	6.25	6.66
2½ x 3	2.50	3.25	3.75	4.38	5.00	5.63	6.25	6.88	7.5	8.25	8.75	9.38	10.00
2½ x 4	3.33	4.16	5.00	5.80	7.50	8.00	8.33	9.16	10.0	10.80	11.66	12.50	13.33
2½ x 5	4.08	5.25	6.25	7.33	8.33	9.40	10.40	11.50	12.5	13.56	14.56	15.66	16.66
2½ x 6	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.0	16.25	17.50	18.75	20.00
2½ x 7	5.80	7.33	8.75	10.16	11.66	13.16	15.00	16.28	17.5	18.75	20.40	21.88	23.33
2½ x 8	6.66	8.33	10.00	11.66	13.33	15.00	16.66	18.33	20.0	21.66	23.33	25.00	26.66
2½ x 9	7.50	9.40	11.25	13.16	15.00	16.88	18.75	20.66	22.5	24.33	26.25	28.08	30.00
2½ x 10	8.33	10.40	12.50	14.56	16.66	18.75	20.80	23.08	25.0	27.08	29.16	31.25	33.33
2½ x 11	9.16	11.50	13.75	16.08	18.33	20.66	23.00	25.25	27.5	29.82	32.16	34.50	36.66
2½ x 12	10.00	12.50	15.00	17.50	20.00	22.50	25.00	27.50	30.0	32.50	35.00	37.50	40.00

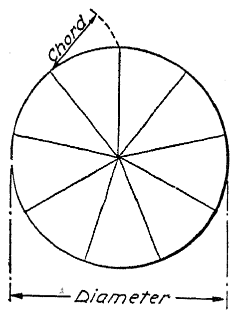
BOARD FEET IN PATTERN LUMBER
(Concluded)

The tables should be used with judgment. That is, do not take the trouble to make a lengthy interpolation, when the accuracy of the final result, in money, would not be changed over one cent. In most cases sufficient accuracy is attained by taking the nearest even dimensions given in the table without further calculation.

	Length in Feet												
Size.	4	5	6	7	8	9	10	11	12	13	14	15	16
	Feet Board Measure												
3 x 1	1.0	1.25	1.5	1.75	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0
3 x 2	2.0	2.50	3.0	3.50	4.0	4.50	5.0	5.50	6.0	6.50	7.0	7.50	8.0
3 x 3	3.0	3.75	4.5	5.25	6.0	6.75	7.5	8.25	9.0	9.75	10.5	11.25	12.0
3 x 4	4.0	5.00	6.0	7.00	8.0	9.00	10.0	11.0	12.0	13.00	14.0	15.00	16.0
3 x 5	5.0	6.25	7.5	8.75	10.0	11.25	12.5	13.75	15.0	16.25	17.5	18.75	20.0
3 x 6	6.0	7.50	9.0	10.50	12.0	13.50	15.0	16.50	18.0	19.50	21.0	22.50	24.0
3 x 7	7.0	8.75	10.5	12.25	14.0	15.75	17.5	19.25	21.0	22.75	24.5	26.25	28.0
3x 8	8.0	10.00	12.0	14.00	16.0	18.00	20.0	22.00	24.0	26.00	28.0	30.00	32.0
3 x 9	9.0	11.25	13.5	15.75	18.0	20.25	22.5	24.75	27.0	29.25	31.5	33.25	36.0
3 x10	10.0	12.50	15.0	17.50	20.0	22.50	25.0	27.50	30.0	32.50	35.0	37.50	40.0
3 x11	11.0	13.75	16.5	20.25	22.0	24.75	27.5	30.25	33.0	35.75	38.5	41.25	44.0
3 x12	12.0	15.00	18.0	21.00	24.0	27.00	30.0	33.00	36.0	39.00	42.0	45.00	48.0

	Feet in Length												
Size.	4	5	6	7	8	9	10	11	12	13	14	15	16
	Feet Board Measure												
4 x 1	1.33	1.66	2.0	2.33	2.66	3.0	3.33	3.66	4.0	4.33	4.66	5.0	5.33
4 x 2	2.66	3.33	4.0	4.66	5.33	6.0	6.66	7.33	8.0	8.66	9.33	10.0	10.66
4 x 3	4.00	5.00	6.0	7.00	8.00	9.0	10.00	11.00	12.0	13.00	14.00	15.0	16.00
4 x 4	5.33	6.66	8.0	9.33	10.66	12.0	13.33	14.66	16.0	17.33	18.66	20.0	21.33
4 x 5	6.66	8.33	10.0	11.66	13.33	15.0	16.66	18.33	20.0	21.66	23.33	25.0	26.66
4 x 6	8.00	10.00	12.0	14.00	16.00	18.0	20.00	22.00	24.0	26.00	28.00	30.0	32.00
4 x 7	9.33	11.66	14.0	16.33	18.66	21.0	23.33	25.66	28.0	30.33	32.66	35.0	37.33
4 x 8	10.66	13.33	16.0	18.66	21.33	24.0	26.66	29.33	32.0	34.66	37.33	40.0	42.66
4 x 9	12.00	15.00	18.0	21.00	24.00	27.0	30.00	33.00	36.0	39.00	42.00	45.0	48.00
4 x10	13.33	16.66	20.0	23.33	26.66	30.0	33.33	36.66	40.0	43.33	46.66	50.0	53.33
4 x11	14.66	18.33	22.0	25.66	29.33	33.0	36.66	40.33	44.0	47.66	51.33	55.0	58.66
4 x12	16.00	20.00	24.0	28.00	32.00	36.0	40.00	44.00	48.0	52.00	56.00	60.0	64.00

LENGTHS OF CHORDS FOR SPACING CIRCLES



If the diameter is in even feet or even inches, the chords can be found directly from the tables below. If the diameter is in feet and inches, add the chord corresponding to the number of even feet to the chord corresponding to the number of even inches in the diameter. For example, find the chord used for spacing the circumference of a circle 6 feet 2 inches in diameter into nine equal spaces.

From table with diameter in feet, chord for 9 spaces, 6 feet.... = 24.6254
From table with diameter in inches, chord for 9 spaces, 2 inches = .6840

Therefore chord for 6 feet, 2 inches, 9 spaces................ = 25.3094

The table for additional fractions is used in the same manner. For 6 spaces, the chord is equal to the radius.

No. of spaces	Length of Chord When Diameter is 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
3	10.3923	20.7846	31.1769	41.5692	51.9615	62.3538	72.7461	83.1384	93.5307	103.9230
4	8.4853	16.9706	25.4558	33.9411	42.4264	50.9117	59.3970	67.8822	76.3675	84.8528
5	7.0534	14.1068	21.1603	28.2137	35.2671	42.3205	49.3740	56.4274	63.4808	70.5342
7	5.2066	10.4132	15.6198	20.8264	26.0330	31.2396	36.4462	41.6528	46.8594	52.0660
8	4.5922	9.1844	13.7766	18.3688	22.9610	27.5532	32.1454	36.7376	41.3298	45.9220
9	4.1042	8.2085	12.3127	16.4170	20.5212	24.6254	28.7297	32.8339	36.9382	41.0424

No. of spaces	Length of Chord When Diameter is 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
3	.8660	1.7321	2.5981	3.4641	4.3301	5.1962	6.0622	6.9282	7.7942	8.6603	9.5263
4	.7071	1.4142	2.1213	2.8284	3.5355	4.2426	4.9497	5.6569	6.3640	7.0711	7.7782
5	.5878	1.1756	1.7634	2.3511	2.9389	3.5267	4.1145	4.7023	5.2901	5.8779	6.4656
7	.4339	.8678	1.3017	1.7355	2.1694	2.6033	3.0372	3.4711	3.9050	4.3388	4.7727
8	.3827	.7654	1.1481	1.5307	1.9134	2.2961	2.6788	3.0615	3.4442	3.8268	4.2095
9	.3420	.6840	1.0261	1.3681	1.7101	2.0521	2.3941	2.7362	3.1782	3.4202	3.7622

Length of Chord To Be Added for Each Additional Fraction of

No. of spaces	1/8 in.	1/4 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.
3	.1083	.2165	.3248	.4330	.5413	.6495	.7578
4	.0884	.1768	.2652	.3536	.4419	.5303	.6187
5	.0735	.1469	.2204	.2939	.3674	.4408	.5143

Length of Chord To Be Added for Each Additional Fraction of

No. of spaces	1/8 in.	1/4 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.
7	.0542	.1085	.1627	.2169	.2712	.3254	.3796
8	.0478	.0957	.1435	.1913	.2392	.2870	.3348
9	.0427	.0855	.1283	.1710	.2138	.2565	.2993

LENGTHS OF CHORDS FOR SPACING CIR

(Continued)

No. of spaces	Length of Chord When Diameter Is 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.
10	3.7082	7.4164	11.1246	14.8328	18.5410	22.2492	25.9574	29.6656
11	3.3808	6.7616	10.1424	13.5232	16.9040	20.2847	23.6655	27.0463
12	3.1058	6.2117	9.3175	12.4233	15.5291	18.6350	21.7408	24.8466
13	2.8718	5.7436	8.6154	11.4872	14.3589	17.2307	20.1025	22.9743
14	2.7602	5.3405	8.0107	10.6810	13.3512	16.0215	18.6917	21.3620
15	2.4949	4.9899	7.4848	9.9798	12.4747	14.9696	17.4646	19.9595
16	2.3411	4.6822	7.0233	9.3643	11.7054	14.0465	16.3876	18.7287
17	2.2050	4.4100	6.6150	8.8200	11.0250	13.2300	15.4350	17.6400
18	2.0838	4.1676	6.2513	8.3351	10.4189	12.5027	14.5864	16.6702
19	1.9751	3.9503	5.9254	7.9005	9.8757	11.8508	13.8259	15.8011
20	1.8772	3.7544	5.6316	7.5089	9.3861	11.2633	13.1405	15.0177
21	1.7885	3.5770	5.3655	7.1540	8.9425	10.7310	12.5195	14.3081
22	1.7078	3.4156	5.1233	6.8311	8.5389	10.2467	11.9544	13.6622
23	1.6340	3.2680	4.9020	6.5360	8.1700	9.8040	11.4380	13.0720
24	1.5663	3.1326	4.6989	6.2653	7.8316	9.3979	10.9642	12.5305
25	1.5040	3.0080	4.5120	6.0160	7.5200	9.0240	10.5280	12.0320

No. of spaces	Length of Chord When Diameter Is 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.
10	.3090	.6170	.9271	1.2361	1.5451	1.8541	2.1631	2.4721	2.7812
11	.2817	.5635	.8452	1.1269	1.4087	1.6904	1.9721	2.3539	2.6356
12	.2588	.5176	.7765	1.0353	1.2941	1.5529	1.8117	2.0706	2.3294
13	.2393	.4786	.7179	.9573	1.1966	1.4359	1.6752	1.9145	2.1538
14	.2225	.4450	.6676	.8901	1.1126	1.3351	1.5576	1.7802	2.0027
15	.2079	.4158	.6237	.8316	1.0396	1.2475	1.4554	1.6633	1.8712
16	.1951	.3902	.5853	.7804	.9755	1.1705	1.3656	1.5607	1.7558
17	.1837	.3675	.5512	.7350	.9187	1.1025	1.2862	1.4700	1.6537
18	.1736	.3473	.5209	.6946	.8682	1.0419	1.2155	1.3892	1.5628
19	.1646	.3292	.4938	.6584	.8230	.9876	1.1522	1.3168	1.4814
20	.1564	.3129	.4693	.6257	.7822	.9386	1.0950	1.2515	1.4079
21	.1490	.2981	.4471	.5962	.7452	.8943	1.0433	1.1923	1.3414
22	.1423	.2846	.4269	.5693	.7116	.8539	.9962	1.1385	1.2808
23	.1362	.2723	.4085	.5447	.6808	.8170	.9532	1.0893	1.2255
24	.1305	.2611	.3916	.5221	.6526	.7832	.9137	1.0442	1.1747
25	.1253	.2507	.3760	.5013	.6267	.7520	.8773	1.0027	1.1280

Length of Chord To Be Added for Each Additional Fraction of

No. of spaces	1/8 in.	1/4 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.
10	.0386	.0773	.1159	.1545	.1931	.2318	.2704
11	.0352	.0704	.1056	.1409	.1761	.2113	.2465
12	.0323	.0657	.0981	.1294	.1618	.1941	.2265
13	.0299	.0598	.0897	.1197	.1496	.1795	.2094
14	.0278	.0556	.0834	.1113	.1391	.1669	.1947
15	.0260	.0520	.0780	.1040	.1299	.1559	.1819
16	.0244	.0488	.0732	.0975	.1219	.1463	.1707
17	.0229	.0459	.0689	.0919	.1148	.1378	.1608

Length of Chord To I
Each Additional F

No. of spaces	1/8 in.	1/4 in.	3/8 in.	1/2 in.
18	.0217	.0434	.0651	.0868
19	.0206	.0411	.0617	.0823
20	.0196	.0391	.0587	.0782
21	.0186	.0373	.0559	.0745
22	.0177	.0356	.0534	.0712
23	.0170	.0340	.0511	.0681
24	.0163	.0326	.0489	.0653
25	.0157	.0313	.0470	.0627

LENGTHS OF CHORDS FOR SPACING CIRCLES

(Continued)

No. of Spaces	Length of Chord When Diameter is 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
26	1.4464	2.8929	4.3393	5.7858	7.2322	8.6785	10.1250	11.5714	13.0179	14.4643
27	1.3931	2.7862	4.1793	5.5725	6.9656	8.3587	9.7518	11.1449	12.5380	13.9311
28	1.3435	2.6871	4.0307	5.3743	6.7179	8.0614	9.4050	10.7486	12.0922	13.4357
29	1.2974	2.5949	3.8923	5.1897	6.4871	7.7846	9.0820	10.3794	11.6768	12.9742
30	1.2543	2.5087	3.7630	5.0174	6.2717	7.5260	8.7804	10.0347	11.2891	12.5434
31	1.2140	2.4280	3.6421	4.8561	6.0701	7.2841	8.4981	9.7122	10.9262	12.1402
32	1.1762	2.3524	3.5286	4.7048	5.8810	7.0572	8.2334	9.4096	10.5858	11.7621
33	1.1407	2.2813	3.4220	4.5627	5.7034	6.8440	7.9847	9.1254	10.0660	11.4067
34	1.1072	2.2144	3.3217	4.4289	5.5361	6.6433	7.7505	8.8578	9.9650	11.0722
35	1.0757	2.1513	3.2270	4.3027	5.3784	6.4540	7.5297	8.6054	9.6810	10.7567
36	1.0459	2.0917	3.1376	4.1835	5.2293	6.2752	7.3211	8.3669	9.4128	10.4587
37	1.0177	2.0353	3.0530	4.0707	5.0883	6.1060	7.1237	8.1414	9.1590	10.1767
38	.9910	1.9819	2.9729	3.9638	4.9548	5.9457	6.9367	7.9276	8.9186	9.9095
39	.9656	1.9312	2.8968	3.8624	4.8280	5.7936	6.7592	7.7248	8.6904	9.6560
40	.9415	1.8830	2.8245	3.7660	4.7075	5.6491	6.5906	7.5321	8.4736	9.4151
41	.9186	1.8372	2.7558	3.6744	4.5930	5.5115	6.4301	7.3487	8.2673	9.1859

No. of Spaces	Length of Chord When Diameter is 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
26	.1205	.2411	.3616	.4821	.6027	.7232	.8438	.9643	1.0848	1.2054	1.3259
27	.1161	.2322	.3483	.4644	.5805	.6966	.8127	.9287	1.0448	1.1609	1.2770
28	.1120	.2239	.3359	.4480	.5598	.6718	.7838	.8957	1.0077	1.1196	1.2316
29	.1081	.2162	.3244	.4324	.5406	.6487	.7568	.8650	.9731	1.0812	1.1893
30	.1045	.2091	.3136	.4181	.5226	.6272	.7317	.8362	.9408	1.0453	1.1498
31	.1012	.2023	.3035	.4047	.5058	.6070	.7082	.8093	.9105	1.0117	1.1129
32	.0980	.1960	.2941	.3921	.4901	.5881	.6861	.7841	.8822	.9802	1.0782
33	.0951	.1901	.2852	.3802	.4753	.5703	.6654	.7604	.8555	.9506	1.0456
34	.0923	.1845	.2768	.3691	.4613	.5536	.6459	.7381	.8304	.9227	1.0150
35	.0896	.1793	.2689	.3586	.4482	.5378	.6275	.7171	.8068	.8964	.9860
36	.0872	.1743	.2615	.3486	.4358	.5229	.6101	.6972	.7844	.8716	.9587
37	.0848	.1696	.2544	.3392	.4240	.5088	.5936	.6784	.7633	.8481	.9329
38	.0826	.1651	.2477	.3303	.4129	.4955	.5781	.6606	.7432	.8258	.9084
39	.0805	.1609	.2414	.3219	.4023	.4828	.5633	.6437	.7242	.8047	.8851
40	.0785	.1569	.2354	.3138	.3923	.4708	.5492	.6277	.7061	.7846	.8631
41	.0765	.1531	.2296	.3062	.3827	.4593	.5358	.6124	.6889	7655	.8420

No. of Spaces	Length of Chord to be Added for Each Additional Fraction of ⅛ in.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
26	.0151	.0301	.0452	.0603	.0753	.0904	.1055
27	.0144	.0288	.0432	.0575	.0719	.0863	.1007
28	.0140	.0280	.0420	.0560	.0700	.0840	.0980
29	.0135	.0270	.0405	.0541	.0676	.0811	.0946
30	.0131	.0261	.0392	.0523	.0653	.0784	.0915
31	.0126	.0253	.0379	.0506	.0632	.0759	.0885
32	.0123	.0245	.0368	.0490	.0613	.0735	.0858
33	.0119	.0238	.0356	.0475	.0594	.0713	.0832

No. of Spaces	Length of Chord to be Added for Each Additional Fraction of ⅛ in.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
34	.0115	.0231	.0346	.0461	.0577	.0692	.0807
35	.0112	.0224	.0336	.0448	.0560	.0672	.0784
36	.0109	.0218	.0327	.0436	.0545	.0654	.0763
37	.0106	.0212	.0318	.0424	.0532	.0636	.0742
38	.0103	.0206	.0310	.0413	.0516	.0619	.0723
39	.0101	.0201	.0302	.0402	.0503	.0603	.0704
40	.0098	.0196	.0294	.0392	.0490	.0588	.0687
41	.0096	.0191	.0287	.0383	.0478	.0574	.0670

LENGTHS OF CHORDS FOR SPACING CIRCLES

(Concluded)

No. of Spaces	Length of Chord When Diameter is 1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
42	.8968	1.7935	2.6903	3.5870	4.4838	5.3806	6.2773	7.1741	8.0709	8.9676
43	.8759	1.7519	2.6278	3.5038	4.3797	5.2557	6.1316	7.0075	7.8835	8.7594
44	.8561	1.7121	2.5682	3.4243	4.2803	5.1364	5.9925	6.8486	7.7046	8.5607
45	.8371	1.6742	2.5112	3.3483	4.1854	5.0225	5.8595	6.6966	7.5337	8.3708
46	.8189	1.6378	2.4567	3.2756	4.0945	4.9134	5.7324	6.5513	7.3702	8.1891
47	.8015	1.6030	2.4045	3.2060	4.0076	4.8091	5.6106	6.4121	7.2136	8.0151
48	.7848	1.5697	2.3545	3.1393	3.9242	4.7090	5.4939	6.2787	7.0635	7.8484
49	.7688	1.5377	2.3065	3.0754	3.8442	4.6131	5.3819	6.1507	6.9196	7.6884
50	.7535	1.5070	2.2605	3.0139	3.7674	4.5209	5.2744	6.0279	6.7814	7.5349
51	.7387	1.4774	2.2162	2.9549	3.6937	4.4324	5.1711	5.9098	6.6486	7.3873
52	.7245	1.4491	2.1736	2.8982	3.6227	4.3472	5.0718	5.7963	6.5209	7.2454
53	.7109	1.4218	2.1327	2.8435	3.5544	4.2653	4.9762	5.6871	6.3980	7.1089
54	.6977	1.3955	2.0932	2.7910	3.4887	4.1864	4.8842	5.5819	6.2796	6.9774
55	.6851	1.3701	2.0552	2.7403	3.4253	4.1104	4.7955	5.4805	6.1656	6.8507
56	.6728	1.3457	2.0185	2.6914	3.3642	4.0731	4.7099	5.3828	6.0556	6.7284
57	.6611	1.3221	1.9382	2.6442	3.3053	3.9663	4.6274	5.2884	5.9495	6.6105

No. of Spaces	Length of Chord When Diameter is 1 in.	2 in.	3 in.	4 in.	5 in.	6 in.	7 in.	8 in.	9 in.	10 in.	11 in.
42	.0747	.1495	.2242	.2989	.3736	.4484	.5231	.5978	.6726	.7473	.8220
43	.0730	.1460	.2190	.2920	.3650	.4380	.5110	.5840	.6570	.7300	.8029
44	.0713	.1427	.2140	.2854	.3567	.4280	.4993	.5707	.6421	.7134	.7847
45	.0698	.1395	.2093	.2790	.3488	.4185	.4883	.5581	.6278	.6976	.7673
46	.0682	.1365	.2047	.2730	.3412	.4095	.4777	.5459	.6142	.6824	.7507
47	.0668	.1336	.2004	.2672	.3340	.4008	.4675	.5343	.6011	.6679	.7347
48	.0654	.1308	.1962	.2616	.3270	.3924	.4578	.5232	.5886	.6540	.7194
49	.0641	.1281	.1922	.2563	.3204	.3844	.4485	.5126	.5766	.6407	.7048
50	.0628	.1256	.1884	.2512	.3140	.3767	.4395	.5023	.5651	.6279	.6907
51	.0616	.1231	.1847	.2462	.3078	.3694	.4309	.4925	.5540	.6156	.6772
52	.0604	.1208	.1811	.2415	.3019	.3623	.4226	.4830	.5434	.6038	.6642
53	.0592	.1184	.1777	.2370	.2962	.3554	.4147	.4739	.5332	.5924	.6516
54	.0581	.1163	.1744	.2326	.2907	.3489	.4070	.4652	.5233	.5814	.6396
55	.0571	.1142	.1713	.2284	.2854	.3425	.3996	.4567	.5138	.5709	.6280
56	.0561	.1121	.1682	.2243	.2804	.3364	.3925	.4486	.5046	.5607	.6168
57	.0551	.1102	.1653	.2204	.2754	.3305	.3856	.4407	.4958	.5509	.6060

No. of Spaces	Length of Chord to be Added for Each Additional Fraction of 1/8 in.	1/4 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.
42	.0093	.0187	.0280	.0374	.0467	.0560	.0654
43	.0091	.0182	.0274	.0365	.0456	.0547	.0639
44	.0089	.0178	.0268	.0357	.0446	.0535	.0624
45	.0087	.0174	.0262	.0349	.0436	.0523	.0610
46	.0085	.0171	.0256	.0341	.0427	.0512	.0597
47	.0083	.0167	.0250	.0334	.0417	.0501	.0584
48	.0082	.0164	.0245	.0327	.0409	.0491	.0572
49	.0080	.0160	.0240	.0320	.0400	.0481	.0561

No. of Spaces	Length of Chord to be Added for Each Additional Fraction of 1/8 in.	1/4 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.
50	.0078	.0157	.0235	.0314	.0392	.0471	.0549
51	.0077	.0154	.0231	.0308	.0385	.0462	.0539
52	.0075	.0151	.0226	.0302	.0377	.0453	.0528
53	.0074	.0148	.0222	.0296	.0370	.0444	.0518
54	.0073	.0145	.0218	.0291	.0363	.0436	.0509
55	.0071	.0143	.0214	.0285	.0357	.0428	.0500
56	.0070	.0140	.0210	.0280	.0350	.0421	.0491
57	.0069	.0138	.0207	.0275	.0344	.0413	.0482

CHORDS OF ANGLES FROM ONE TO NINETY DEGREES

Many cases will occur in building and laying-out patterns, where a square protractor or bevel cannot be used, and in such cases this table will be of service. It will be observed that the 10-inch radius can be easily taken on a 12-inch scale, the 22-inch radius on a 24-inch scale, and the 48-inch radius by laying down two lengths of the 24-inch scale.

To lay-out the required angle, scribe an arc, using one of the given radii, then set the trammels to the length of the chord given in the table for the required angle, layout on the circle and connect these points with the center.

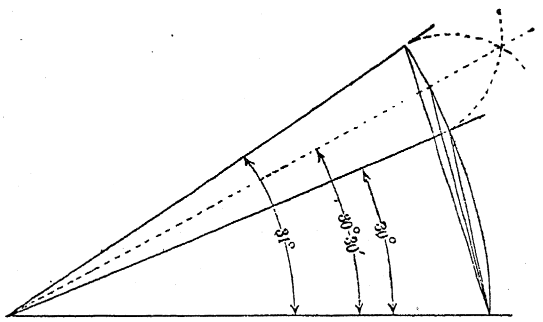
Angle in degrees	10-inch radius	22-inch radius	48-inch radius	Angle in degrees	10-inch radius	22-inch radius	48-inch radius
1	11/64	3/8	13/16	16	2 25/32	6 7/64	13 11/32
2	23/64	49/64	1 11/16	17	2 31/32	6 33/64	14 13/64
3	33/64	1 9/64	2 1/2	18	3 9/64	6 57/64	15 1/64
4	45/64	1 35/64	3 23/64	19	3 19/64	7 17/64	15 27/32
5	7/8	1 59/64	4 11/64	20	3 15/32	7 5/8	16 21/32
6	1 3/64	2 5/16	5 3/64	21	3 41/64	8 1/64	17 15/32
7	1 7/32	2 11/16	5 53/64	22	3 53/64	8 13/32	18 21/64
8	1 25/64	3 1/16	6 43/64	23	4	8 25/32	19 5/32
9	1 37/64	3 29/64	7 17/32	24	4 5/32	9 5/32	19 31/32
10	1 3/4	3 53/64	8 23/64	25	4 21/64	9 17/32	20 25/32
11	1 59/64	4 21/64	9 7/32	26	4 1/2	9 29/32	21 39/64
12	2 3/32	4 19/32	10 1/32	27	4 43/64	10 9/32	22 13/32
13	2 17/64	4 31/32	10 27/32	28	4 27/32	10 41/64	23 15/64
14	2 7/16	5 3/8	11 23/32	29	5 1/64	11 1/64	24 3/64
15	2 39/64	5 47/64	12 33/64	30	5 3/16	11 25/64	24 55/64

CHORDS OF ANGLES FROM ONE TO NINETY DEGREES
(Continued)

Angle in degrees	10-inch radius	22-inch radius	48-inch radius	Angle in degrees	10-inch radius	22-inch radius	48-inch radius
31	5 11/32	11 47/64	25 41/64	61	10 5/32	22 21/64	48 45/64
32	5 33/64	12 1/8	26 7/16	62	10 5/16	22 21/32	49 7/16
33	5 11/16	12 1/2	27 9/32	63	10 29/64	22 63/64	50 5/32
34	5 55/64	12 7/8	28 5/64	64	10 39/64	23 21/64	50 7/8
35	6 1/64	13 7/32	28 27/32	65	10 3/4	23 21/32	51 39/64
36	6 3/16	13 19/32	29 21/32	66	10 57/64	23 61/64	52 17/64
37	6 23/64	13 31/32	30 31/64	67	11 3/64	24 9/32	53
38	6 33/64	14 21/64	31 15/64	68	11 3/16	24 19/32	53 21/32
39	6 11/16	14 11/16	31 55/64	69	11 23/64	24 59/64	54 25/64
40	6 27/32	15 3/64	32 53/64	70	11 31/64	25 15/64	55 3/64
41	7	15 13/32	33 39/64	71	11 39/64	25 35/64	55 23/64
42	7 11/64	15 25/32	34 27/32	72	11 49/64	25 7/8	56 7/16
43	7 21/64	16 1/8	35 3/16	73	11 29/32	26 3/16	57 1/8
44	7 1/2	16 31/64	35 61/64	74	12 3/64	26 31/64	57 51/64
45	7 21/32	16 53/64	36 23/32	75	12 11/64	26 49/64	58 27/64
46	7 25/32	17 3/16	37 31/64	76	12 5/16	27 5/64	59 5/64
47	7 31/32	17 17/32	38 1/4	77	12 29/64	27 25/64	59 49/64
48	8 1/8	17 7/8	39 1/64	78	12 19/32	27 11/16	60 7/16
49	8 19/64	18 15/64	39 51/64	79	12 23/32	27 63/64	61 3/64
50	8 29/64	18 19/32	40 9/16	80	12 55/64	28 19/64	61 23/32
51	8 39/64	18 15/16	41 21/64	81	13	28 37/64	62 3/8
52	8 49/64	19 19/64	42 3/32	82	13 1/8	28 55/64	62 31/32
53	8 59/64	19 5/8	42 13/16	83	13 1/4	29 5/32	63 39/64
54	9 5/64	19 31/32	43 37/64	84	13 3/8	29 7/16	64 7/32
55	9 15/64	20 19/64	44 13/32	85	13 33/64	29 23/32	64 27/32
56	9 25/64	20 21/32	45 5/64	86	13 41/64	30	65 15/32
57	9 35/64	20 63/64	45 51/64	87	13 49/64	30 19/64	66 3/32
58	9 45/64	21 11/32	46 9/16	88	13 57/64	30 9/16	66 43/64
59	9 55/64	21 43/64	47 9/32	89	14 1/64	30 27/32	67 19/64
60	10	22	48	90	14 9/64	31 7/64	67 7/8

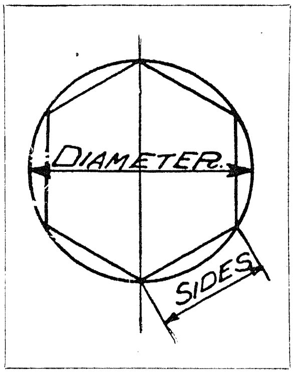
CHORDS OF ANGLES FROM ONE TO NINETY DEGREES
(Concluded)

Ang. Deg.	18" Radius Chord	36" Radius Chord	72" Radius Chord	Ang. Deg.	18" Radius Chord	36" Radius Chord	72" Radius Chord
1	5/16	5/8	1 1/4	46	14 1/16	28 1/8	56 17/64
2	5/8	1 1/4	2 1/2	47	14 23/64	28 23/32	57 27/64
3	15/16	1 7/8	3 3/4	48	14 41/64	29 9/32	58 37/64
4	1 1/4	2 1/2	5	49	14 59/64	29 55/64	59 23/32
5	1 37/64	3 9/64	6 9/32	50	15 7/32	30 27/64	60 55/64
6	1 7/8	3 49/64	7 17/32	51	15 1/2	31	62
7	2 13/64	4 25/64	8 51/64	52	15 25/32	31 9/16	63 1/8
8	2 1/2	5 1/64	10 3/64	53	16 1/16	32 1/8	64 1/4
9	2 53/64	5 41/64	11 19/64	54	16 11/32	32 11/16	65 3/8
10	3 9/64	6 9/32	12 35/64	55	16 5/8	33 1/4	66 1/2
11	3 29/64	6 29/32	13 51/64	56	16 29/32	33 51/64	67 39/64
12	3 49/64	7 17/32	15 3/64	57	17 11/64	34 23/64	68 23/32
13	4 5/64	8 5/32	16 19/64	58	17 29/64	34 29/32	69 13/16
14	4 25/64	8 25/32	17 35/64	59	17 23/32	35 29/64	70 29/32
15	4 45/64	9 25/64	18 51/64	60	18	36	72
16	5	10 1/64	20 1/32	61	18 17/64	36 35/64	73 5/64
17	5 21/64	10 41/64	21 9/32	62	18 35/64	37 5/64	74 11/64
18	5 5/8	11 17/64	22 17/32	63	18 13/16	37 5/8	75 1/4
19	5 15/16	11 7/8	23 49/64	64	19 5/64	38 5/32	76 5/16
20	6 1/4	12 1/2	25	65	19 11/32	38 11/16	77 3/8
21	6 9/16	13 1/8	26 15/64	66	19 39/64	39 7/32	78 27/64
22	6 7/8	13 47/64	27 31/64	67	19 7/8	39 47/64	79 15/32
23	7 11/64	14 23/64	28 45/64	68	20 1/8	40 17/64	80 17/32
24	7 31/64	14 31/32	29 15/16	69	20 25/64	40 25/32	81 9/16
25	7 51/64	15 37/64	31 11/64	70	20 41/64	41 19/64	82 19/32
26	8 3/32	16 13/64	32 25/64	71	20 29/32	41 13/16	83 5/8
27	8 13/32	16 13/16	33 5/8	72	21 5/32	42 21/64	84 41/64
28	8 45/64	17 13/32	34 13/16	73	21 13/32	42 53/64	85 21/32
29	9 1/64	18 1/32	36 1/16	74	21 21/32	43 21/64	86 21/32
30	9 5/16	18 41/64	37 17/64	75	21 59/64	43 53/64	87 21/32
31	9 5/8	19 15/64	38 31/64	76	22 5/32	44 21/64	88 21/32
32	9 59/64	19 27/32	39 11/16	77	22 13/32	44 53/64	89 41/64
33	10 7/32	20 29/64	40 57/64	78	22 21/32	45 5/16	90 5/8
34	10 17/32	21 3/64	42 3/32	79	22 57/64	45 51/64	91 19/32
35	10 53/64	21 21/32	43 19/64	80	23 9/64	46 9/32	92 9/16
36	11 1/8	22 1/4	44 1/2	81	23 3/8	46 3/4	93 33/64
37	11 27/64	22 27/32	45 11/16	82	23 39/64	47 15/64	94 15/32
38	11 23/32	23 7/16	46 7/8	83	23 55/64	47 45/64	95 13/32
39	12 1/64	24 1/32	48 1/16	84	24 3/32	48 11/64	96 23/64
40	12 5/16	24 5/8	49 1/4	85	24 21/64	48 41/64	97 9/32
41	12 39/64	25 7/32	50 7/16	86	24 35/64	49 3/32	98 13/64
42	12 29/32	25 51/64	51 39/64	87	24 25/32	49 9/16	99 1/8
43	13 3/16	26 25/64	52 25/32	88	25	50 1/64	100 1/32
44	13 31/64	26 31/32	53 15/16	89	25 15/64	50 15/32	100 15/16
45	13 25/32	27 35/64	55 7/64	90	25 29/64	50 29/32	101 53/64



Chords of intermediate angles can be obtained as shown on the diagram.

TABLE OF DIMENSIONS OF POLYGONS



$$\text{Co-efficient} = \frac{\text{Diameter}}{\text{Side}} \qquad \text{Side} = \frac{\text{Diameter}}{\text{Co-efficient}}$$

$$\text{Diameter} = \text{Co-efficient} \times \text{Side}$$

No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.	No. of Sides	Coef.
3	1.16	28	8.93	53	16.88	78	24.83	103	32.79	128	40.75
4	1.41	29	9.25	54	17.20	79	25.15	104	33.11	129	41.07
5	1.70	30	9.57	55	17.52	80	25.47	105	33.43	130	41.38
6	2.00	31	9.88	56	17.83	81	25.79	106	33.74	131	41.70
7	2.31	32	10.20	57	18.15	82	26.11	107	34.06	132	42.02
8	2.61	33	10.52	58	18.47	83	26.43	108	34.38	133	42.34
9	2.93	34	10.84	59	18.79	84	26.74	109	34.70	134	42.66
10	3.24	35	11.16	60	19.11	85	27.06	110	35.02	135	42.98
11	3.55	36	11.47	61	19.42	86	27.38	111	35.34	136	43.29
12	3.86	37	11.79	62	19.74	87	27.70	112	35.65	137	43.61
13	4.18	38	12.11	63	20.06	88	28.02	113	35.97	138	43.93
14	4.49	39	12.43	64	20.38	89	28.33	114	36.29	139	44.25
15	4.81	40	12.74	65	20.70	90	28.65	115	36.61	140	44.57
16	5.12	41	13.06	66	21.02	91	28.97	116	36.93	141	44.88
17	5.44	42	13.38	67	21.33	92	39.29	117	37.25	142	45.20
18	5.76	43	13.70	68	21.65	93	29.61	118	37.56	143	45.52
19	6.07	44	14.02	69	21.97	94	29.93	119	37.88	144	45.84
20	6.39	45	14.33	70	22.29	95	30.24	120	38.20	145	46.16
21	6.71	46	14.65	71	22.61	96	30.56	121	38.52	146	46.48
22	7.03	47	14.97	72	22.92	97	30.88	122	38.84	147	46.79
23	7.34	48	15.29	73	23.24	98	31.20	123	39.16	148	47.11
24	7.66	49	15.61	74	23.56	99	31.52	124	39.47	149	47.43
25	7.98	50	15.93	75	23.88	100	31.84	125	39.79	150	47.75
26	8.30	51	16.24	76	24.20	101	32.15	126	40.11	151	48.07
27	8.61	52	16.56	77	24.52	102	32.47	127	40.43	152	48.39

OUTSIDE DIAMETERS FOR POLYGONS

In laying out and making patterns many cases occur where squares, hexagons or octagons must be scribed. The first step in this operation is to lay out a circle of proper diameter inside of which the polygon may be constructed. The accompanying tables give the proper diameters for these circles for polygons ranging from 1-16 to 6 inches across flats.

Distance across flats, inches	Dia. for squares, inches	Dia. for hexagons, inches	Dia. for octagons, inches	Distance across flats, inches	Dia. for squares, inches	Dia. for hexagons, inches	Dia. for octagons inches
1/16	3/32	5/64	1/16	1 1/4	1 49/64	1 7/16	1 23/64
1/8	11/64	9/64	9/64	1 5/16	1 55/64	1 33/64	1 27/64
3/16	17/64	7/32	13/64	1 3/8	1 15/16	1 19/32	1 31/64
1/4	23/64	9/32	17/64	1 7/16	2 1/32	1 21/32	1 9/16
5/16	7/16	23/64	11/32	1 1/2	2 1/8	1 47/64	1 5/8
3/8	17/32	7/16	13/32	1 9/16	2 13/64	1 51/64	1 11/16
7/16	5/8	1/2	15/32	1 5/8	2 19/64	1 7/8	1 49/64
1/2	45/64	37/64	35/64	1 11/16	2 25/64	1 61/64	1 53/64
9/16	51/64	21/32	39/64	1 3/4	2 15/32	2 1/64	1 57/64
5/8	57/64	23/32	43/64	1 13/16	2 9/16	2 3/32	1 31/32
11/16	31/32	51/64	3/4	1 7/8	2 21/32	2 11/64	2 1/32
3/4	1 1/16	55/64	13/16	1 15/16	2 47/64	2 15/64	2 3/32
13/16	1 5/32	15/16	7/8	2	2 53/64	2 5/16	2 11/64
7/8	1 15/64	1 1/64	61/64	2 1/16	2 59/64	2 3/8	2 15/64
15/16	1 21/64	1 5/64	1 1/64	2 1/8	3	2 29/64	2 19/64
1	1 27/64	1 5/32	1 5/64	2 3/16	3 3/32	2 17/32	2 3/8
1 1/16	1 1/2	1 15/64	1 5/32	2 1/4	3 3/16	2 19/32	2 7/16
1 1/8	1 19/32	1 19/64	1 7/32	2 5/16	3 17/64	2 43/64	2 1/2
1 3/16	1 11/16	1 3/8	1 9/32	2 3/8	3 23/64	2 3/4	2 37/64

OUTSIDE DIAMETERS FOR POLYGONS

(Concluded)

Distance across flats, inches	Dia. for squares, inches	Dia. for hexagons, inches	Dia. for octagons, inches	Distance across flats, inches	Dia. for squares, inches	Dia. for hexagons, inches	Dia. for Octagons, inches
2 7/16	3 29/64	2 13/16	2 41/64	4 1/4	6 1/64	4 29/32	4 19/32
2 1/2	3 17/32	2 57/64	2 45/64	4 5/16	6 3/32	4 63/64	4 43/64
2 9/16	3 5/8	2 61/64	2 25/32	4 3/8	6 3/16	5 3/64	4 47/64
2 5/8	3 23/32	3 1/32	2 27/32	4 7/16	6 9/32	5 1/8	4 51/64
2 11/16	3 51/64	3 7/64	2 29/32	4 1/2	6 23/64	5 13/64	4 7/8
2 3/4	3 57/64	3 11/64	2 63/64	4 9/16	6 29/64	5 17/64	4 15/16
2 13/16	3 63/64	3 1/4	3 3/64	4 5/8	6 35/64	5 11/32	5 1/64
2 7/8	4 1/16	3 5/16	3 7/64	4 11/16	6 5/8	5 13/32	5 5/64
2 15/16	4 5/32	3 25/64	3 11/64	4 3/4	6 23/32	5 31/64	5 9/64
3	4 1/4	3 15/32	3 1/4	4 13/16	6 13/16	5 9/16	5 13/64
3 1/16	4 21/64	3 17/32	3 5/16	4 7/8	6 57/64	5 5/8	5 9/32
3 1/8	4 27/64	3 39/64	3 3/8	4 15/16	6 63/64	5 45/64	5 11/32
3 3/16	4 1/2	3 11/16	3 29/64	5	7 5/64	5 49/64	5 13/32
3 1/4	4 19/32	3 3/4	3 33/64	5 1/16	7 5/32	5 27/32	5 31/64
3 5/16	4 11/16	3 53/64	3 37/64	5 1/8	7 1/4	5 59/64	5 35/64
3 3/8	4 49/64	3 57/64	3 21/32	5 3/16	7 11/32	5 63/64	5 39/64
3 7/16	4 55/64	3 31/32	3 23/32	5 1/4	7 27/64	6 1/16	5 11/16
3 1/2	4 61/64	4 3/64	3 25/32	5 5/16	7 33/64	6 9/64	5 3/4
3 9/16	5 1/32	4 7/64	3 55/64	5 3/8	7 19/32	6 13/64	5 13/16
3 5/8	5 1/8	4 3/16	3 59/64	5 7/16	7 11/16	6 9/32	5 57/64
3 11/16	5 7/32	4 17/64	3 63/64	5 1/2	7 25/32	6 11/32	5 61/64
3 3/4	5 19/64	4 21/64	4 1/16	5 9/16	7 55/64	6 27/64	6 1/64
3 13/16	5 25/64	4 13/32	4 1/8	5 5/8	7 61/64	6 1/2	6 3/32
3 7/8	5 31/64	4 15/32	4 3/16	5 11/16	8 3/64	6 9/16	6 5/32
3 15/16	5 9/16	4 35/64	4 17/64	5 3/4	8 1/8	6 41/64	6 7/32
4	5 21/32	4 5/8	4 21/64	5 13/16	8 7/32	6 23/32	6 19/64
4 1/16	5 3/4	4 11/16	4 25/64	5 7/8	8 5/16	6 25/32	6 23/64
4 1/8	5 53/64	4 49/64	4 15/32	5 15/16	8 25/64	6 55/64	6 27/64
4 3/16	5 59/64	4 53/64	4 17/32	6	8 31/64	6 59/64	6 1/2

LENGTHS OF SIDES OF POLYGONS

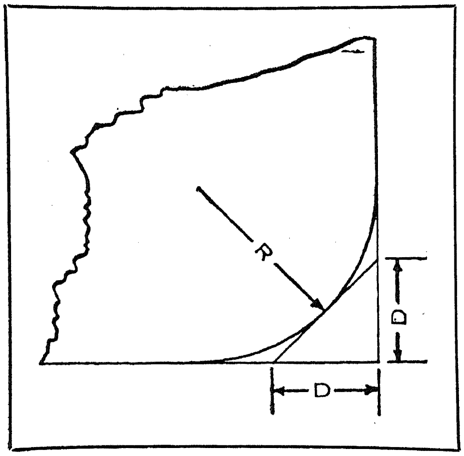
Tables are presented on pages 134 and 135 giving the correct diameters for circles circumscribing squares, hexagons and octagons of various sizes ranging from 1/16 to 6 inches across flats. In order to lay out these polygons on a pattern with a pair of dividers it is necessary also to know the length of one side of the polygon. These data are given in the accompanying tables.

Distance across flats, inches	Length for squares, inches	Length for hexagons, inches	Length for octagons, inches	Distance across flats, inches	Length for squares, inches	Length for hexagons, inches	Length for octagons, inches
1/16	1/16	1/32	1/32	1 1/4	1 1/4	23/32	33/64
1/8	1/8	5/64	3/64	1 5/16	1 5/16	3/4	35/64
3/16	3/16	7/64	5/64	1 3/8	1 3/8	51/64	9/16
1/4	1/4	9/64	7/64	1 7/16	1 7/16	53/64	19/32
5/16	5/16	3/16	1/8	1 1/2	1 1/2	55/64	5/8
3/8	3/8	7/32	5/32	1 9/16	1 9/16	29/32	41/64
7/16	7/16	1/4	3/16	1 5/8	1 5/8	15/16	43/64
1/2	1/2	9/32	13/64	1 11/16	1 11/16	31/32	45/64
9/16	9/16	21/64	15/64	1 3/4	1 3/4	1 1/64	23/32
5/8	5/8	23/64	17/64	1 13/16	1 13/16	1 3/64	3/4
11/16	11/16	25/64	9/32	1 7/8	1 7/8	1 5/64	25/32
3/4	3/4	7/16	5/16	1 15/16	1 15/16	1 1/8	51/64
13/16	13/16	15/32	11/32	2	2	1 5/32	53/64
7/8	7/8	1/2	23/64	2 1/16	2 1/16	1 3/16	55/64
15/16	15/16	35/64	25/64	2 1/8	2 1/8	1 7/32	7/8
1	1	37/64	13/32	2 3/16	2 3/16	1 17/64	29/32
1 1/16	1 1/16	39/64	7/16	2 1/4	2 1/4	1 19/64	15/16
1 1/8	1 1/8	21/32	15/32	2 5/16	2 5/16	1 21/64	61/64
1 3/16	1 3/16	11/16	31/64	2 3/8	2 3/8	1 3/8	63/64

LENGTHS OF SIDES OF POLYGONS
(Concluded)

Distance across flats, inches.	Length for squares, inches.	Length for hexagons, inches.	Length for octagons, inches.	Distance across flats, inches.	Length for squares, inches.	Length for hexagons, inches.	Length for octagons inches.
$2\frac{7}{16}$	$2\frac{7}{16}$	$1\frac{13}{32}$	$1\frac{1}{64}$	$4\frac{1}{4}$	$4\frac{1}{4}$	$2\frac{29}{64}$	$1\frac{49}{64}$
$2\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{7}{16}$	$1\frac{1}{32}$	$4\frac{5}{16}$	$4\frac{5}{16}$	$2\frac{31}{64}$	$1\frac{25}{32}$
$2\frac{9}{16}$	$2\frac{9}{16}$	$1\frac{31}{64}$	$1\frac{1}{16}$	$4\frac{3}{8}$	$4\frac{3}{8}$	$2\frac{17}{32}$	$1\frac{13}{16}$
$2\frac{5}{8}$	$2\frac{5}{8}$	$1\frac{33}{64}$	$1\frac{3}{32}$	$4\frac{7}{16}$	$4\frac{7}{16}$	$2\frac{9}{16}$	$1\frac{27}{32}$
$2\frac{11}{16}$	$2\frac{11}{16}$	$1\frac{35}{64}$	$1\frac{7}{64}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{19}{32}$	$1\frac{55}{64}$
$2\frac{3}{4}$	$2\frac{3}{4}$	$1\frac{19}{32}$	$1\frac{9}{64}$	$4\frac{9}{16}$	$4\frac{9}{16}$	$2\frac{41}{64}$	$1\frac{57}{64}$
$2\frac{13}{16}$	$2\frac{13}{16}$	$1\frac{5}{8}$	$1\frac{11}{64}$	$4\frac{5}{8}$	$4\frac{5}{8}$	$2\frac{43}{64}$	$1\frac{59}{64}$
$2\frac{7}{8}$	$2\frac{7}{8}$	$1\frac{21}{32}$	$1\frac{3}{16}$	$4\frac{11}{16}$	$4\frac{11}{16}$	$2\frac{45}{64}$	$1\frac{15}{16}$
$2\frac{15}{16}$	$2\frac{15}{16}$	$1\frac{45}{64}$	$1\frac{7}{32}$	$4\frac{3}{4}$	$4\frac{3}{4}$	$2\frac{3}{4}$	$1\frac{31}{32}$
3	3	$1\frac{47}{64}$	$1\frac{15}{64}$	$1\frac{13}{16}$	$4\frac{13}{16}$	$2\frac{25}{32}$	2
$3\frac{1}{16}$	$3\frac{1}{16}$	$1\frac{49}{64}$	$1\frac{17}{64}$	$4\frac{7}{8}$	$4\frac{7}{8}$	$2\frac{13}{16}$	$2\frac{1}{64}$
$3\frac{1}{8}$	$3\frac{1}{8}$	$1\frac{51}{64}$	$1\frac{19}{64}$	$4\frac{15}{16}$	$4\frac{15}{16}$	$2\frac{27}{32}$	$2\frac{3}{64}$
$3\frac{3}{16}$	$3\frac{3}{16}$	$1\frac{27}{32}$	$1\frac{5}{16}$	5	5	$2\frac{57}{64}$	$2\frac{1}{16}$
$3\frac{1}{4}$	$3\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{11}{32}$	$5\frac{1}{16}$	$5\frac{1}{16}$	$2\frac{59}{64}$	$2\frac{3}{32}$
$3\frac{5}{16}$	$3\frac{5}{16}$	$1\frac{29}{32}$	$1\frac{3}{8}$	$5\frac{1}{8}$	$5\frac{1}{8}$	$2\frac{61}{64}$	$2\frac{1}{8}$
$3\frac{3}{8}$	$3\frac{3}{8}$	$1\frac{61}{64}$	$1\frac{25}{64}$	$5\frac{3}{16}$	$5\frac{3}{16}$	3	$2\frac{9}{64}$
$3\frac{7}{16}$	$3\frac{7}{16}$	$1\frac{63}{64}$	$1\frac{27}{64}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$3\frac{1}{32}$	$2\frac{11}{64}$
$3\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{1}{64}$	$1\frac{29}{64}$	$5\frac{5}{16}$	$5\frac{5}{16}$	$3\frac{1}{16}$	$2\frac{13}{64}$
$3\frac{9}{16}$	$3\frac{9}{16}$	$2\frac{1}{16}$	$1\frac{15}{32}$	$5\frac{3}{8}$	$5\frac{3}{8}$	$3\frac{7}{64}$	$2\frac{7}{32}$
$3\frac{5}{8}$	$3\frac{5}{8}$	$2\frac{3}{32}$	$1\frac{1}{2}$	$5\frac{7}{16}$	$5\frac{7}{16}$	$3\frac{9}{64}$	$2\frac{1}{4}$
$3\frac{11}{16}$	$3\frac{11}{16}$	$2\frac{1}{8}$	$1\frac{17}{32}$	$5\frac{1}{2}$	$5\frac{1}{2}$	$3\frac{11}{64}$	$2\frac{9}{32}$
$3\frac{3}{4}$	$3\frac{3}{4}$	$2\frac{11}{64}$	$1\frac{35}{64}$	$5\frac{9}{16}$	$5\frac{9}{16}$	$3\frac{7}{32}$	$2\frac{19}{64}$
$3\frac{13}{16}$	$3\frac{13}{16}$	$2\frac{13}{64}$	$1\frac{37}{64}$	$5\frac{5}{8}$	$5\frac{5}{8}$	$3\frac{1}{4}$	$2\frac{21}{64}$
$3\frac{7}{8}$	$3\frac{7}{8}$	$2\frac{15}{64}$	$1\frac{39}{64}$	$5\frac{11}{16}$	$5\frac{11}{16}$	$3\frac{9}{32}$	$2\frac{23}{64}$
$3\frac{15}{16}$	$3\frac{15}{16}$	$2\frac{17}{64}$	$1\frac{5}{8}$	$5\frac{3}{4}$	$5\frac{3}{4}$	$3\frac{5}{16}$	$2\frac{3}{8}$
4	4	$2\frac{5}{16}$	$1\frac{21}{32}$	$5\frac{13}{16}$	$5\frac{13}{16}$	$3\frac{23}{64}$	$2\frac{13}{32}$
$4\frac{1}{16}$	$4\frac{1}{16}$	$2\frac{11}{32}$	$1\frac{11}{16}$	$5\frac{7}{8}$	$5\frac{7}{8}$	$3\frac{25}{64}$	$2\frac{7}{16}$
$4\frac{1}{8}$	$4\frac{1}{8}$	$2\frac{3}{8}$	$1\frac{45}{64}$	$5\frac{15}{16}$	$5\frac{15}{16}$	$3\frac{27}{64}$	$2\frac{29}{64}$
$4\frac{3}{16}$	$4\frac{3}{16}$	$2\frac{27}{64}$	$1\frac{47}{64}$	6	6	$3\frac{15}{32}$	$2\frac{31}{64}$

PATTERNMAKER'S TABLE FOR ROUNDING CORNERS



R=Radius

D=Distance to be scribed from each corner, the corner is flattened down to these lines and the remaining small fins can be easily rounded over.

R		1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
	D	1/32	5/64	7/64	9/64	3/16	7/32	1/4	19/64	21/64	23/64	13/32	7/16	31/64	33/64	35/64
1	37/64	5/8	21/32	45/64	47/64	49/64	51/64	27/32	7/8	59/64	61/64	63/64	1 1/32	1 1/16	1 3/32	1 9/64
2	1 1/64		1 1/4		1 5/16		1 13/32		1 15/32		1 35/64		1 5/8		1 45/64	
3	1 49/64		1 53/64		1 29/32		1 31/32		2 3/64		2 1/8		2 3/16		2 17/64	
4	2 11/32		2 27/64		2 31/64		2 9/16		2 41/64		2 23/32		2 25/32		2 55/64	
5	2 15/16		3		3 5/64		3 5/32		3 7/32		3 19/64		3 23/64		3 7/16	
6	3 33/64				3 21/32				3 13/16				3 61/64			
7	4 7/64				4 1/4				4 25/64				4 35/64			
8	4 11/16				4 53/64				4 63/64				5 1/8			
9	5 17/64				5 27/64				5 9/16				5 23/32			
10	5 55/64															

How the Table Is Used

The values for *D* corresponding to radius measurements of less than 1 inch, are indicated in the line of fractional values immediately beneath the ruled line. Thus the value of *D* when *R* is 1/4, is 9/64. To find the corresponding values when *R* is greater than 1, follow the horizontal line across from the whole number of the dimension to where it intersects the vertical column under the desired fractional value in the top line. Thus, to find the value of *D* when *R* is 2 1/2, trace the line horizontally across from 2, in the left hand column, until the value immediately beneath 1/2 is found. Here the value for *D* will be found to be 1 15/32.

TAPERS AND ANGLES

Taper per Foot in Inches

	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4

Corresponding Angles for Tapers

No.				1°	1°	1°	2°	2°	2°	3°	4°	4°	5°	5°
of	17′	35′	53′	11′	29′	47′	5′	23′	59′	34′	10′	46′	21′	57′
in.	54″	48″	44″	36″	30″	24″	18″	10″	42″	44″	32″	18″	44″	48″

Taper per Inch in Inches

1	0.0052	0.0104	0.0156	1/64	1/64	1/32	1/32	3/64	3/64	1/16	5/64	5/64	3/32	7/64
2	0.0104	0.0208	0.0313	3/64	3/64	1/16	5/64	5/64	7/64	1/8	9/64	11/64	3/16	13/64
3	0.0156	0.0312	0.0469	1/16	5/64	3/32	7/64	1/8	5/32	3/16	7/32	1/4	9/32	5/16
4	0.0208	0.0417	0.0625	5/64	7/64	1/8	9/64	11/64	13/64	1/4	19/64	21/64	3/8	27/64
5	0.0260	0.0521	0.0781	7/64	1/8	5/32	3/16	13/64	17/64	5/16	23/64	27/64	15/32	33/64
6	0.0312	0.0625	0.0938	1/8	5/32	3/16	7/32	1/4	5/16	3/8	7/16	1/2	9/16	5/8
7	0.0365	0.0729	0.1094	9/64	3/16	7/32	1/4	19/64	23/64	7/16	33/64	37/64	21/32	47/64
8	0.0417	0.0833	0.1250	11/64	13/64	1/4	19/64	21/64	27/64	1/2	37/64	43/64	3/4	53/64
9	0.0469	0.0937	0.1406	3/16	15/64	9/32	21/64	3/8	15/32	9/16	21/32	3/4	27/32	15/16
10	0.0521	0.1042	0.1563	13/64	17/64	5/16	23/64	27/64	33/64	5/8	47/64	53/64	15/16	1 3/64
11	0.0573	0.1146	0.1719	15/64	9/32	11/32	13/32	29/64	37/64	11/16	51/64	59/64	1 1/32	1 9/64
12	0.0625	0.1250	0.1875	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4

TAPERS AND ANGLES
(Concluded)

TAPER PER FOOT IN INCHES

1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 5/8	2 3/4	2 7/8	3

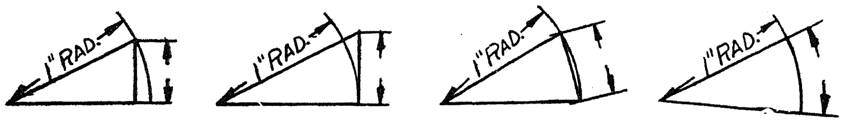
CORRESPONDING ANGLES FOR TAPERS

No.	6°	7°	7°	8°	8°	9°	10°	10°	11°	11°	12°	13°	13°	14°
of	33′	9′	44′	20′	56′	31′	7′	42′	18′	53′	29′	4′	39′	15′
in.	26″	10″	48″	26″	2″	36″	10″	42″	10″	36″	2″	24″	42″	

TAPER PER INCH IN INCHES

1	7/64	1/8	9/64	9/64	5/32	11/64	11/64	3/16	13/64	13/64	7/32	15/64	15/64	1/4
2	15/64	1/4	17/64	19/64	5/16	21/64	23/64	3/8	25/64	27/64	7/16	29/64	31/64	1/2
3	11/32	3/8	13/32	7/16	15/32	1/2	17/32	9/16	19/32	5/8	21/32	11/16	23/32	3/4
4	29/64	1/2	35/64	37/64	5/8	43/64	45/64	3/4	51/64	53/64	7/8	59/64	61/64	1
5	37/64	5/8	43/64	47/64	25/32	53/64	57/64	15/16	63/64	1 3/64	1 3/32	1 9/64	1 13/64	1 1/4
6	11/16	3/4	13/16	7/8	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2
7	51/64	7/8	61/64	1 1/64	1 3/32	1 11/64	1 15/64	1 5/16	1 25/64	1 29/64	1 17/32	1 39/64	1 43/64	1 3/4
8	59/64	1	1 5/64	1 11/64	1 1/4	1 21/64	1 27/64	1 1/2	1 37/64	1 43/64	1 3/4	1 53/64	1 59/64	2
9	1 1/32	1 1/8	1 7/32	1 5/16	1 13/32	1 1/2	1 19/32	1 11/16	1 25/32	1 7/8	1 31/32	2 1/16	2 5/32	2 1/4
10	1 9/64	1 1/4	1 23/64	1 29/64	1 9/16	1 43/64	1 49/64	1 7/8	1 63/64	2 5/64	2 3/16	2 19/64	2 25/64	2 1/2
11	1 17/64	1 3/8	1 31/64	1 39/64	1 23/32	1 53/64	1 61/64	2 1/16	2 11/64	2 19/64	2 13/32	2 33/64	2 41/64	2 3/4
12	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8	2 1/2	2 5/8	2 3/4	2 7/8	3

TABLE OF SINES, TANGENTS, CHORDS AND CIRCULAR ARCS



SINE TANGENT CHORD CIRCULAR ARC

DEG.	FOR 1-INCH RADIUS	FOR 1-INCH RADIUS	FOR 1-INCH RADIUS	FOR 1-INCH RADIUS
1	.0175	.0175	.0175	.0175
2	.0349	.0349	.0349	.0349
3	.0523	.0524	.0524	.0524
4	.0698	.0699	.0698	.0698
5	.0872	.0875	.0872	.0873
6	.1045	.1051	.1047	.1047
7	.1219	.1228	.1221	.1222
8	.1392	.1405	.1395	.1396
9	.1564	.1584	.1569	.1571
10	.1737	.1763	.1743	.1745
11	.1908	.1944	.1917	.1920
12	.2079	.2126	.2091	.2094
13	.2250	.2309	.2264	.2269
14	.2419	.2493	.2437	.2443
15	.2588	.2680	.2611	.2618
16	.2756	.2868	.2783	.2793
17	.2924	.3057	.2956	.2967
18	.3090	.3249	.3129	.3142
19	.3256	.3443	.3301	.3316
20	.3420	.3640	.3473	.3491
21	.3584	.3839	.3645	.3665
22	.3746	.4040	.3816	.3840
23	.3907	.4245	.3987	.4014
24	.4067	.4452	.4158	.4189
25	.4226	.4663	.4329	.4363
26	.4384	.4877	.4499	.4538
27	.4540	.5095	.4669	.4712
28	.4695	.5317	.4838	.4887
29	.4848	.5543	.5008	.5061
30	.5000	.5774	.5176	.5236
31	.5150	.6009	.5345	.5411
32	.5299	.6249	.5513	.5585
33	.5446	.6494	.5680	.5760
34	.5592	.6745	.5847	.5934
35	.5736	.7002	.6014	.6109
36	.5878	.7265	.6180	.6283
37	.6018	.7536	.6346	.6458
38	.6157	.7813	.6511	.6632
39	.6293	.8098	.6676	.6807
40	.6428	.8391	.6840	.6981

TABLE OF SINES, TANGENTS, CHORDS AND CIRCULAR ARCS

(Concluded)

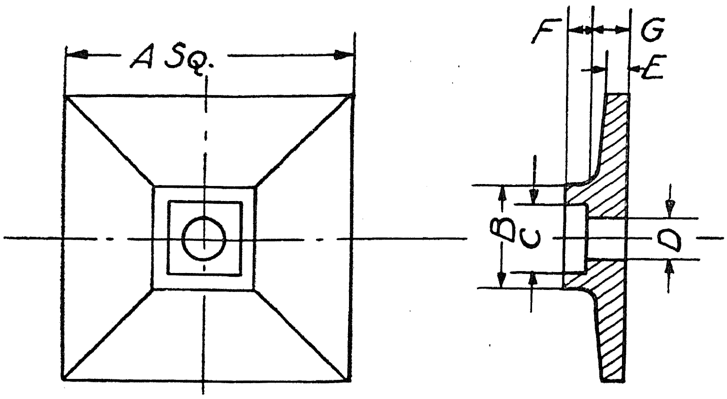
DEG.	FOR 1-INCH RADIUS	FOR 1-INCH RADIUS	FOR 1-INCH RADIUS	FOR 1-INCH RADIUS
41	.6561	.8693	.7004	.7156
42	.6691	.9004	.7167	.7330
43	.6820	.9325	.7330	.7505
44	.6947	.9657	.7492	.7679
45	.7071	1.0000	.7654	.7854
46	.7193	1.0355	.7815	.8029
47	.7314	1.0724	.7975	.8203
48	.7431	1.1106	.8135	.8378
49	.7547	1.1504	.8294	.8552
50	.7660	1.1918	.8452	.8727
51	.7772	1.2349	.8610	.8901
52	.7880	1.2799	.8767	.9076
53	.7986	1.3270	.8924	.9250
54	.8090	1.3764	.9080	.9425
55	.8192	1.4282	.9235	.9599
56	.8290	1.4826	.9389	.9774
57	.8387	1.5399	.9543	.9948
58	.8481	1.6003	.9696	1.0123
59	.8572	1.6643	.9848	1.0297
60	.8660	1.7321	1.0000	1.0472
61	.8746	1.8041	1.0151	1.0647
62	.8830	1.8807	1.0301	1.0821
63	.8910	1.9626	1.0450	1.0996
64	.8988	2.0503	1.0598	1.1170
65	.9063	2.1445	1.0746	1.1345
66	.9136	2.2460	1.0893	1.1519
67	.9205	2.3559	1.1039	1.1694
68	.9272	2.4751	1.1184	1.1868
69	.9336	2.6051	1.1328	1.2043
70	.9397	2.7475	1.1472	1.2217
71	.9455	2.9042	1.1614	1.2392
72	.9511	3.0777	1.1756	1.2566
73	.9563	3.2709	1.1896	1.2741
74	.9613	3.4874	1.2036	1.2915
75	.9659	3.7321	1.2175	1.3090
76	.9703	4.0108	1.2313	1.3265
77	.9744	4.3315	1.2450	1.3439
78	.9782	4.7046	1.2586	1.3614
79	.9816	5.1446	1.2722	1.3788
80	.9848	5.6713	1.2856	1.3963
81	.9877	6.3138	1.2989	1.4137
82	.9903	7.1154	1.3121	1.4312
83	.9926	8.1444	1.3252	1.4486
84	.9945	9.5144	1.3383	1.4661
85	.9962	11.4301	1.3512	1.4835
86	.9976	14.3007	1.3640	1.5010
87	.9986	19.0811	1.3767	1.5184
88	.9994	28.6363	1.3893	1.5359
89	.9999	57.2900	1.4018	1.5533
90	1.0000	....	1.4142	1.5708

FINDING LENGTHS OF CHORD

To Find the Length of a Chord to Divide the Circumference of a Circle into *N* Equal Parts, Multiply *S* by the Diameter

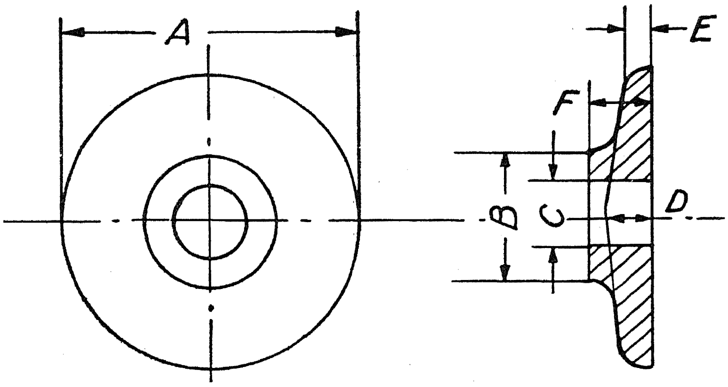
N	S	N	S	N	S	N	S
1		26	.12054	51	.061560	76	.041325
2		27	.11609	52	.060379	77	.040788
3	.86603	28	.11197	53	059240	78	.040267
4	.70711	29	.10812	54	.058145	79	.039757
5	.58779	30	.10453	55	.057090	80	.039260
6	.50000	31	.10117	56	.056071	81	.038775
7	.43388	32	.098018	57	.055089	82	.038303
8	.38268	33	.095056	58	.054139	83	.037841
9	.34202	34	.092269	59	.053222	84	.037391
10	.30902	35	.089640	60	.052336	85	.036953
11	.28173	36	.087156	61	.051478	86	.036522
12	.25882	37	.084804	62	.050649	87	.036103
13	.23932	38	.082580	63	.049845	88	.035692
14	.22252	39	.080466	64	.049068	89	.035291
15	.20791	40	.078460	65	.048312	90	.034899
16	.19509	41	.076549	66	.047582	91	.034516
17	.18375	42	.074731	67	.046872	92	.034141
18	.17365	43	.072995	68	.046184	93	.033774
19	.16460	44	.071339	69	.045515	94	.033415
20	.15643	45	.069756	70	.044865	95	.033064
21	.14904	46	.068243	71	.044232	96	.032719
22	.14232	47	.066793	72	.043619	97	.032381
23	.13617	48	.065401	73	.043022	98	.032051
24	.13053	49	.064073	74	.042441	99	.031728
25	.12533	50	.062791	75	.041875	100	.031411

STANDARD FOUNDATION WASHERS



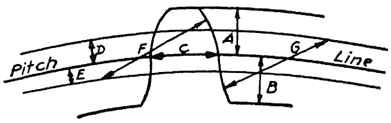
Diam. of Bolt	A	B	C	D	E	F	G	Est. Wt. Lbs. C. Steel
½"	5"	1½"	1 "	9/16"	⅜"	⅜"	⅝"	3.68
⅝	5	1 11/16	1 3/16	11/16	⅜	⅜	⅝	3.75
¾	6	1⅞	1⅜	13/16	½	½	¾	6.6
⅞	6	2 1/16	1 9/16	15/16	½	½	¾	6.6
1	7	2½	1¾	1⅛	⅝	⅝	⅞	11.
1⅛	7	2 11/16	1 15/16	1¼	⅝	⅝	⅞	11.
1¼	8	2⅞	2⅛	1⅜	⅝	⅝	1	15.2
1½	8	3¼	2½	1⅝	⅝	⅝	1	15.1
1¾	10	3⅞	2⅞	1⅞	¾	¾	1½	33.
2	10	4¼	3¼	2⅛	¾	¾	1½	33.
2¼	12	4⅞	3⅝	2⅜	⅞	1	2	60.6
2½	12	5¼	4	2⅝	⅞	1	2	61.
2¾	15	5⅞	4⅜	2⅞	1	1¼	2¼	107.8
3	15	6¼	4¾	3⅛	1	1¼	2¼	107.6
3¼	18	6⅝	5⅛	3⅜	1⅛	1½	2¾	182.9
3½	18	7	5½	3⅝	1⅛	1½	2¾	182.7

STANDARD WOOD WASHERS



Diam. of Bolt	A	B	C	D	E	F	Est. Wt. Lbs. C. Steel
1/4"	1 1/4"	5/8"	5/16"	3/16"	1/8"	1/4"	.06
3/8	1 7/8	7/8	7/16	5/16	3/16	3/8	.18
1/2	2 1/2	1 1/4	5/8	3/8	1/4	1/2	.42
5/8	3 1/8	1 1/2	3/4	1/2	3/8	5/8	.83
3/4	3 3/4	1 3/4	7/8	5/8	3/8	3/4	1.46
7/8	4 3/8	2	1	3/4	3/8	7/8	2.14
1	5	2 1/4	1 1/8	7/8	7/16	1	3.32
1 1/8	5 5/8	2 1/2	1 1/4	1	1/2	1 1/8	4.72
1 1/4	6 1/4	2 3/4	1 3/8	1	1/2	1 1/4	6.06
1 3/8	6 7/8	3	1 1/2	1 1/8	1/2	1 3/8	7.67
1 1/2	7 1/2	3 1/4	1 5/8	1 1/4	9/16	1 1/2	10.21
1 5/8	8 1/8	3 1/2	1 3/4	1 1/4	5/8	1 5/8	12.68
1 3/4	8 3/4	3 3/4	1 7/8	1 3/8	3/4	1 3/4	17.35
2	10	4 1/4	2 1/8	1 1/2	7/8	2	24.9

EPICYCLOIDAL GEAR TEETH



A=0.3 x pitch=distance between the pitch and addendum circles.

B=0.375 x pitch=distance between pitch and root circles.

C=0.466 x pitch=thickness of gear tooth.

D=distance from pitch circle to line of flank centers.

E=distance from pitch circle to radius base line.

F=face radius of gear tooth.

G=flank radius of gear tooth.

Table I

Values for Layout of 12-Tooth Gear

Pitch	A	B	C	D*	E	F	G*
1/2	5/32	3/16	15/64	..	1/64	5/16	..
3/4	7/32	9/32	11/32	..	1/64	31/64	..
1	5/16	3/8	15/32	..	1/32	41/64	..
1 1/8	11/32	27/64	17/32	..	1/32	23/32	..
1 1/4	3/8	15/32	37/64	..	1/32	13/16	..
1 3/8	13/32	33/64	41/64	..	1/32	7/8	..
1 1/2	7/16	9/16	11/16	..	1/32	31/32	..
1 5/8	1/2	5/8	3/4	..	1/32	1 3/64	..
1 3/4	17/32	21/32	13/16	..	1/32	1 1/8	..
1 7/8	9/16	45/64	7/8	..	1/32	1 3/16	..
2	19/32	3/4	15/16	..	3/64	1 9/32	..
2 1/4	43/64	27/32	1 3/64	..	3/64	1 7/16	..
2 1/2	3/4	15/16	1 5/32	..	3/64	1 39/64	..
2 3/4	53/64	1 1/32	1 9/32	..	3/64	1 3/4	..
3	29/32	1 1/8	1 13/32	..	1/16	1 59/64	..
3 1/4	31/32	1 7/32	1 33/64	..	1/16	2 3/32	..
3 1/2	1 3/64	1 5/16	1 5/8	..	1/16	2 1/4	..
4	1 13/64	1 1/2	1 55/64	..	5/64	2 9/16	..

Table II

Values for Layout of 13-14-Tooth Gear

Pitch	A	B	C	D	E	F	G
1/2	5/32	3/16	15/64	1 1/2	1/64	3/8	2 13/32
3/4	7/32	9/32	11/32	2 1/4	1/64	1/2	3 5/8
1	5/16	3/8	15/32	3	1/32	21/32	4 13/16
1 1/8	11/32	27/64	17/32	3 3/8	1/32	3/4	5 13/32
1 1/4	3/8	13/32	37/64	3 3/4	1/32	13/16	6
1 3/8	13/32	33/64	41/64	4 1/8	1/32	29/32	6 5/8
1 1/2	7/16	9/16	11/16	4 1/2	1/32	31/32	7 13/64
1 5/8	1/2	5/8	3/4	4 7/8	1/32	1 1/16	7 5/8
1 3/4	17/32	21/32	13/16	5 1/4	1/32	1 9/64	8 13/32
1 7/8	9/16	45/64	7/8	5 5/8	3/64	1 13/64	9
2	19/32	3/4	15/16	6	3/64	1 5/16	9 5/8
2 1/4	4 3/64	27/32	1 3/64	6 3/4	3/64	1 15/32	10 15/16
2 1/2	3/4	15/16	1 5/32	7 1/2	3/64	1 5/8	12
2 3/4	53/64	1 1/32	1 9/32	8 1/4	3/64	1 25/32	13 7/32
3	29/32	1 1/8	1 13/32	9	1/16	1 61/64	14 13/32
3 1/4	31/32	1 7/16	1 33/64	9 3/4	1/16	2 1/8	15 5/8
3 1/2	1 3/64	1 5/16	1 5/8	10 1/2	1/16	2 9/32	16 13/32
4	1 13/64	1 1/2	1 55/64	12	5/64	2 39/64	19 3/16

*In this chart for 12 teeth only, the dimensions D and G are omitted as the flanks may be formed with sufficient accuracy from the radii given for the face.

EPICYCLOIDAL GEAR TEETH
(Continued)

Table III

Values for Layout of 15-16-Tooth Gear

Pitch	A	B	C	D	E	F	G
1/2	5/32	3/16	15/64	9/16	1/64	11/32	1 1/4
3/4	7/32	9/32	11/32	53/64	1/32	1/2	1 7/8
1	5/16	3/8	15/32	1 3/32	1/32	43/64	2 1/2
1 1/8	11/32	27/64	17/32	1 15/16	1/32	3/4	2 13/16
1 1/4	3/8	15/32	37/64	1 3/8	1/32	53/64	3 1/8
1 3/8	13/32	33/64	41/64	1 33/64	3/64	7/8	3 7/16
1 1/2	7/16	9/16	11/16	1 21/32	3/64	1	3 3/4
1 5/8	1/2	5/8	3/4	1 25/32	3/64	1 3/32	4 1/16
1 3/4	17/32	21/32	13/16	1 15/16	1/16	1 11/64	4 3/8
1 7/8	9/16	45/64	7/8	2 1/16	1/16	1 1/4	4 11/16
2	19/32	3/4	15/16	2 13/16	1/16	1 11/32	5
2 1/4	43/64	27/32	1 3/64	2 15/32	1/16	1 1/2	5 5/8
2 1/2	3/4	15/16	1 5/32	2 3/4	5/64	1 43/64	6 1/4
2 3/4	59/64	1 1/32	1 9/32	3 1/32	5/64	1 27/32	6 7/8
3	29/32	1 1/8	1 13/32	3 5/16	3/32	2 1/64	7 1/2
3 1/4	31/32	1 9/32	1 33/64	3 9/16	7/64	2 3/16	8 1/8
3 1/2	1 3/64	1 5/16	1 5/8	3 7/8	7/64	2 11/32	8 3/4
4	1 13/64	1 1/2	1 55/64	4 13/32	1/8	2 11/16	10

Table IV

Values for Layout of 17-18-Tooth Gear

Pitch	A	B	C	D	E	F	G
1/2	5/32	13/16	15/64	23/64	1/64	11/32	31/32
3/4	7/32	9/32	11/32	17/32	1/32	33/64	1 15/32
1	5/16	3/8	15/32	45/64	3/64	11/16	1 61/64
1 1/8	11/32	27/64	17/32	25/32	3/64	49/64	2 3/16
1 1/4	3/8	15/32	37/64	7/8	3/64	55/64	2 7/16
1 3/8	13/32	33/64	41/64	31/32	3/64	15/16	2 11/16
1 1/2	7/16	9/16	11/16	1 1/16	1/16	1 1/32	2 15/16
1 5/8	1/2	5/8	3/4	1 1/8	1/16	1 7/64	3 7/64
1 3/4	17/32	21/32	13/16	1 7/32	5/64	1 1/8	3 7/16
1 7/8	9/16	45/64	7/8	1 5/16	5/64	1 1/4	3 21/32
2	19/32	3/4	15/16	1 13/32	5/64	1 23/64	3 29/32
2 1/4	43/64	27/32	1 3/64	1 37/64	3/32	1 17/32	4 1/8
2 1/2	3/4	15/16	1 5/32	1 3/4	7/64	1 45/64	4 7/8
2 3/4	53/64	1 1/32	1 9/32	1 59/64	7/64	1 7/8	5 3/8
3	29/32	1 1/8	1 13/32	2 7/64	1/8	2 3/64	5 55/64
3 1/4	31/32	1 7/32	1 33/64	2 9/32	1/8	2 7/32	6 11/32
3 1/2	1 3/64	1 5/16	1 5/8	2 29/64	9/64	2 3/8	6 53/64
4	1 13/64	1 1/2	1 55/64	2 13/16	5/32	2 23/32	7 13/16

Table V

Values for Layout of 19-21-Tooth Gear

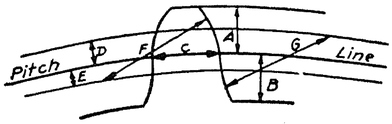
Pitch	A	B	C	D	E	F	G
1/2	5/32	3/16	15/64	1/4	1/64	23/64	13/16
3/4	7/32	9/32	11/32	3/8	1/32	17/32	1 7/32
1	5/16	3/8	15/32	1/2	3/64	45/64	1 5/8
1 1/8	11/32	27/64	17/32	9/16	3/64	25/32	1 27/32
1 1/4	3/8	15/32	37/64	5/8	3/64	7/8	2 1/32
1 3/8	13/32	33/64	41/64	11/16	3/64	31/32	2 1/4
1 1/2	7/16	9/16	11/16	3/4	1/16	1 1/16	2 7/16
1 5/8	1/2	5/8	3/4	13/16	1/16	1 1/8	2 21/32
1 3/4	17/32	21/32	13/16	7/8	5/64	1 7/32	2 55/64
1 7/8	9/16	45/64	7/8	15/16	5/64	1 5/16	3 5/32
2	19/32	3/4	15/16	1	5/64	1 13/32	3 17/64
2 1/4	43/64	27/32	1 3/64	1 1/8	3/32	1 37/64	3 21/32
2 1/2	3/4	15/16	1 5/32	1 1/4	7/64	1 3/4	4 5/64
2 3/4	53/64	1 1/32	1 9/32	1 3/8	7/64	1 59/64	4 31/64
3	29/32	1 1/8	1 13/32	1 1/2	1/8	2 7/64	4 25/32
3 1/4	31/32	1 7/32	1 33/64	1 5/8	1/8	2 9/32	5 19/64
3 1/2	1 3/64	1 5/16	1 5/8	1 3/4	9/64	2 29/64	5 23/32
4	1 13/64	1 1/2	1 55/64	2	5/32	2 13/16	6 33/64

Table VI

Values for Layout of 22-24-Tooth Gear

Pitch	A	B	C	D	E	F	G
1/2	5/32	3/16	15/64	3/16	1/32	23/64	23/32
3/4	7/32	9/32	11/32	17/64	1/32	35/64	1 5/64
1	5/16	3/8	15/32	23/64	3/64	23/32	1 7/16
1 1/8	11/32	27/64	17/32	13/32	1/16	13/16	1 39/64
1 1/4	3/8	15/32	37/64	29/64	1/16	29/32	1 25/32
1 3/8	13/32	33/64	41/64	31/64	1/16	63/64	1 31/32
1 1/2	7/16	9/16	11/16	35/64	5/64	1 5/64	2 9/64
1 5/8	1/2	5/8	3/4	19/32	5/64	1 11/64	2 21/64
1 3/4	17/32	21/32	13/16	5/8	3/32	1 17/64	2 1/2
1 7/8	9/16	45/64	7/8	11/16	3/32	1 23/64	2 11/16
2	19/32	3/4	15/16	23/32	7/64	1 7/16	2 7/8
2 1/4	43/64	27/32	1 3/64	13/16	7/64	1 5/8	3 9/32
2 1/2	3/4	15/16	1 5/32	29/32	1/8	1 13/16	3 37/64
2 3/4	53/64	1 1/32	1 9/32	1	9/64	1 13/64	3 15/16
3	29/32	1 1/8	1 13/32	1 5/64	5/32	2 5/32	4 19/64
3 1/4	31/32	1 7/32	1 33/64	1 11/16	5/32	2 11/32	4 41/64
3 1/2	1 3/64	1 5/16	1 5/8	1 1/4	11/64	2 33/64	5
4	1 13/64	1 1/2	1 55/64	1 7/16	13/64	2 7/8	5 23/32

EPICYCLOIDAL GEAR TEETH
(Continued)



A=0.3 x pitch=distance between the pitch and addendum circles.

B=0.375 x pitch=distance between pitch and root circles.

C=0.466 x pitch=thickness of gear tooth.

D=distance from pitch circle to line of flank centers.

E=distance from pitch circle to radius base line.

F=face radius of gear tooth.

G=flank radius of gear tooth.

Table VII

Values for Layout of 25-29-Tooth Gear

Pitch	A	B	C	D	E	F	G
1/2	5/32	3/16	15/64	9/64	1/32	3/8	31/32
3/4	7/32	9/32	11/32	7/32	1/32	9/16	31/32
1	5/16	3/8	15/32	5/16	3/64	3/4	1 5/16
1 1/8	11/32	27/64	17/32	21/64	1/16	27/32	1 15/32
1 1/4	3/8	15/32	37/64	23/64	1/16	15/16	1 5/8
1 3/8	13/32	33/64	41/64	13/32	1/16	1 1/64	1 25/32
1 1/2	7/16	9/16	11/16	7/16	5/64	1 7/64	1 61/64
1 5/8	1/2	5/8	3/4	15/32	5/64	1 13/64	2 7/64
1 3/4	17/32	21/32	13/16	1/2	3/32	1 19/64	2 9/32
1 7/8	9/16	45/64	7/8	35/64	3/32	1 25/64	2 7/16
2	19/32	3/4	15/16	37/64	7/64	1 31/64	2 19/32
2 1/4	43/64	27/32	1 3/64	21/32	7/64	1 21/32	2 15/16
2 1/2	3/4	15/16	1 5/32	23/32	1/8	1 7/8	3 1/4
2 3/4	53/64	1 1/32	1 9/32	51/64	9/64	2 1/32	3 9/16
3	29/32	1 1/8	1 13/32	7/8	5/32	2 7/32	3 29/32
3 1/4	31/32	1 7/32	1 33/64	15/16	5/32	2 13/32	4 7/32
3 1/2	1 3/64	1 5/16	1 5/8	1 1/64	11/64	2 19/32	4 9/16
4	1 13/64	1 1/2	1 55/64	1 5/32	13/64	2 31/32	5 13/64

Table VIII

Values for Layout of 30-36-Tooth Gear

Pitch	A	B	C	D	E	F	G
1/2	5/32	3/16	15/64	7/64	1/32	3/8	39/64
3/4	7/32	9/32	11/32	11/64	3/64	9/16	29/32
1	5/16	3/8	15/32	15/64	1/16	49/64	1 1/8
1 1/8	11/32	27/64	17/32	1/4	5/64	27/32	1 23/64
1 1/4	3/8	15/32	37/64	9/32	5/64	61/64	1 1/2
1 3/8	13/32	33/64	41/64	5/16	3/32	1 3/64	1 21/32
1 1/2	7/16	9/16	11/16	11/32	3/32	1 7/64	1 13/16
1 5/8	1/2	5/8	3/4	3/8	3/32	1 1/8	1 61/64
1 3/4	17/32	21/32	13/16	13/32	7/64	1 11/32	2 7/64
1 7/8	9/16	45/64	7/8	7/16	7/64	1 27/64	2 1/4
2	19/32	3/4	15/16	15/32	1/8	1 17/32	2 13/32
2 1/4	43/64	27/32	1 3/64	33/64	9/64	1 23/32	2 11/16
2 1/2	3/4	15/16	1 5/32	37/64	5/32	1 29/32	3
2 3/4	53/64	1 1/32	1 9/32	5/8	5/32	2 3/32	3 19/64
3	29/32	1 1/8	1 13/32	11/16	3/16	2 9/32	3 19/32
3 1/4	31/32	1 7/32	1 33/64	3/4	13/64	2 15/32	3 29/32
3 1/2	1 3/64	1 5/16	1 5/8	13/16	7/32	2 21/32	4 13/64
4	1 13/64	1 1/2	1 55/64	59/64	15/64	3 3/64	4 13/16

EPICYCLOIDAL GEAR TEETH
(Concluded)

Table IX

Values for Layout of 37-38-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	3/32	1/32	25/64	9/16
¾	7/32	9/32	11/32	5/32	3/64	19/32	27/32
1	5/16	⅜	15/32	13/64	5/64	51/64	1⅛
1⅛	11/32	27/64	17/32	7/32	5/64	57/64	1¼
1¼	⅜	15/32	37/64	¼	3/32	1	1 13/32
1⅜	13/32	33/64	41/64	9/32	3/32	1 3/32	1 35/64
1½	7/16	9/16	11/16	19/64	7/64	1 3/16	1 11/16
1⅝	½	⅝	¾	21/64	7/64	1 9/32	1 53/64
1¾	17/32	21/32	13/16	11/32	⅛	1⅜	1 31/32
1⅞	9/16	45/64	⅞	⅜	⅛	1 15/32	2 3/32
2	19/32	¾	15/16	13/32	9/64	1 19/32	2¼
2¼	43/64	27/32	1 3/64	29/64	5/32	1 25/32	2 17/32
2½	¾	15/16	1 5/32	½	11/64	1 31/32	2 51/64
2¾	53/64	1 1/32	1 9/32	35/64	13/64	2 11/64	3 5/64
3	29/32	1⅛	1 13/32	39/64	13/64	2⅜	3 23/64
3¼	31/32	1 7/32	1 33/64	21/32	7/32	2 9/16	3 41/64
3½	1 3/64	1 5/16	1⅝	45/64	15/64	2¾	3 59/64
4	1 13/64	1½	1 55/64	51/64	9/32	3 1/16	4½

Table X

Values for Layout of 49-72-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	5/64	3/64	13/32	17/32
¾	7/32	9/32	11/32	⅛	1/16	⅝	51/64
1	5/16	⅜	15/32	11/64	5/64	27/32	1 1/16
1⅛	11/32	27/64	17/32	3/16	3/32	15/16	1 3/16
1¼	⅜	15/32	37/64	7/32	7/64	1 1/32	1 21/64
1⅜	13/32	33/64	41/64	15/64	7/64	1 7/64	1 15/32
1½	7/16	9/16	11/16	¼	⅛	1¼	1 19/32
1⅝	½	⅝	¾	17/64	9/64	1 11/32	1 23/32
1¾	17/32	21/32	13/16	19/64	9/64	1 29/64	1 27/32
1⅞	9/16	45/64	⅞	5/16	5/32	1 9/16	2
2	19/32	¾	15/16	11/32	5/32	1 21/32	2⅛
2¼	43/64	27/32	1 3/64	25/64	11/64	1⅞	2⅜
2½	¾	15/16	1 5/32	27/64	13/64	2 5/64	2 21/32
2¾	53/64	1 1/32	1 9/32	15/32	7/32	2 9/32	2 29/32
3	29/32	1⅛	1 13/32	33/64	¼	2½	3 3/16
3¼	31/32	1 7/32	1 33/64	35/64	17/64	2 11/16	3 7/16
3½	1 3/64	1 5/16	1⅝	19/32	9/32	2 29/32	3 23/32
4	1 13/64	1½	1 55/64	11/16	21/64	3 5/16	4¼

Table XI

Values for Layout of 73-144-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	5/64	3/64	29/64	½
¾	7/32	9/32	11/32	7/64	1/16	43/64	¾
1	5/16	⅜	15/32	9/64	3/32	29/32	1
1⅛	11/32	27/64	17/32	5/32	7/64	1 1/64	1⅛
1¼	⅜	15/32	37/64	11/64	7/64	1 7/64	1¼
1⅜	13/32	33/64	41/64	3/16	⅛	1 15/64	1⅜
1½	7/16	9/16	11/16	7/32	9/64	1 23/64	1½
1⅝	½	⅝	¾	15/64	9/64	1 15/32	1⅝
1¾	17/32	21/32	13/16	¼	5/32	1 9/16	1¾
1⅞	9/16	45/64	⅞	17/64	11/64	1 11/16	1⅞
2	19/32	¾	15/16	9/32	3/16	1 13/16	2
2¼	43/64	27/32	1 3/64	5/16	13/64	2 1/32	2¼
2½	¾	15/16	1 5/32	11/32	7/32	2¼	2½
2¾	53/64	1 1/32	1 9/32	25/64	¼	2 15/32	2¾
3	29/32	1⅛	1 13/32	27/64	17/64	2 45/64	3
3¼	31/32	1 7/32	1 33/64	29/64	19/64	2 59/64	3¼
3½	1 3/64	1 5/16	1⅝	½	5/16	3 5/32	3½
4	1 13/64	1½	1 55/64	9/16	23/64	3 39/64	4

Table XII

Values for Layout of 145-Tooth Gear or Rack*

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	1/16	3/64	15/32	15/32
¾	7/32	9/32	11/32	3/32	5/64	45/64	23/32
1	5/16	⅜	15/32	⅛	7/64	15/16	61/64
1⅛	11/32	27/64	17/32	9/64	7/64	1 3/64	1 1/16
1¼	3/64	15/32	37/64	5/32	⅛	1 5/32	1 3/16
1⅜	13/32	33/64	41/64	11/64	9/64	1 9/32	1 19/64
1½	7/16	9/16	11/16	3/16	5/32	1 25/64	1 27/64
1⅝	½	⅝	¾	13/64	5/32	1 33/64	1 35/64
1¾	17/32	21/32	13/16	7/32	11/64	1⅝	1 21/32
1⅞	9/16	45/64	⅞	7/32	3/16	1¾	1 25/32
2	19/32	¾	15/16	15/64	13/64	1 55/64	1 29/32
2¼	43/64	27/32	1 3/64	9/32	7/32	2 3/32	2 9/64
2½	¾	15/16	1 5/32	19/64	¼	2 21/64	2⅜
2¾	53/64	1 1/32	1 9/32	21/64	9/32	2 35/64	2 39/64
3	29/32	1⅛	1 13/32	23/64	5/16	2 51/64	2 55/64
3¼	31/32	1 7/32	1 33/64	25/64	21/64	3 1/32	3 3/32
3½	1 3/64	1 5/16	1⅝	27/64	23/64	3¼	3 21/64
4	1 13/64	1½	1 55/64	31/64	13/32	3 23/32	3 51/64

*The dimensions here given may be used for any gear with 145 or more teeth or for a straight rack.

EXHAUST CONNECTIONS

Sizes of Exhaust Connections for Wood-Working Machinery

Type of machines	No. of connections	Diameter of pipe, inches
Swing saws: Small size on dry kiln umber, large on wet	1	3½ to 6
Rip saws: Dry kiln material	1	4
Not dry kiln material	1	4½
Self-feed saws	1	5
Table saws:	1	4
For box factory work	1	4½
Mitre saws	1	4
Variety saws	1	4
Variety saws with dado head	1	5
Double saws	2	5
Gang saw (Dependent on size and number of saws)	.	6 to 9
Band saws:		
Blade under 2 inches wide	1	4
Blade 2 inches to 3 inches	1	5
Blade 3 inches to 4 inches	1	6
Blade 4 inches to 6 inches	1	7
Blade 6 inches to 8 inches	1	8
Jig saws	1	4
Tenoning: Single head	1	5
Double head	2	7
Double end, double head	4	10
Variety molder or shaper: Single head	1	4½
Double head	2	6
Double head, heavy work	2	8
Sanders:		
Belt—Less than 6 inches wide	1	4½
Belt—6 to 8 and 10 inches wide	1	5
Belt—12 and 14 inches	1	6
Drum—24 inches long	1	4
Drum—30 inches long	1	5
Drum—36 inches long	1	6
Drum—48 inches long	1	8
Drum—Over 48 inches	1	10
Discs—24 inches diameter	1	5
Discs—26 inches to 36 inches	1	6
Discs—36 inches to 48 inches	1	7
Arm sander	1	4
Planers, matchers, molders, stickers, jointers, etc. (all top and bottom heads)I		
Knives 6 inches to 8 inches	*	5
Knives 9 inches to 14 inches	*	6
Knives 15 inches to 20 inches	*	7
Knives 22 inches to 26 inches	*	8
Knives 28 inches to 36 inches	*	9
Side knives under 15 inches	*	4½
16-20 inches	*	5
21-24 inches	*	6

*One hood for each cutter.

The above table gives the sizes of connections commonly used with wood-working machines, but it is not intended to restrict the pipe to these diameters, as the size varies with the quantity of shavings, the kind of lumber, its condition, whether wet or dry, and the variation in speed of the cutter heads. Modern high-speed machines require larger connection than older types, even though the cutters be of the same size. Experience will dictate just what increase is necessary.

MISCELLANEOUS DATA FOR THE PATTERNMAKER

Frequently pipe connections are made to castings and the patternmaker has to figure on cores of proper size to admit the pipe. The finished diameters of the cored holes for various sizes of pipe are given, with other information, in the pipe table below. The table of wood screw data shows the size drills to use in drilling patterns for screws of various sizes. The sizes of drills less than ¼-inch diameter are given in Brown & Sharpe wire gage numbers. The fillet table gives the principal dimensions of leather fillets.

WROUGHT IRON PIPE DATA

Size, inches	⅛	¼	⅜	½	¾	1	1¼	1½	2
Actual external diam.	0.405	0.54	0.675	0.84	1.05	1.32	1.66	1.90	2.38
Actual internal diam.	0.27	0.364	0.494	0.623	0.824	1.05	1.38	1.61	2.07
No. of threads	27	18	18	14	14	11½	11½	11½	8
Size of tap drill. (Cored holes must be finished to this diameter)	21–64	29–64	19/32	23/32	15/16	1 3/16	1 15/32	1 29/32	2 3/16
Size, inches	2½	3	3½	4	4½	5	6	7	8
Actual external diam.	2.88	3.5	4	4.5	5	5.56	6.63	7.63	8.63
Actual internal diam.	2.47	3.07	3.54	4.03	4.51	5.04	6.07	7.023	7.982
No. of threads	8	8	8	8	8	8	8	8	8
Size of tap drill. (Cored holes must be finished to this diameter)	2⅝	3¼	3¾	4¼	4¾	5 5/16	6 5/16	7⅜	8⅜

WOOD SCREW DATA

No. of screw	20	18	16	14	12	10	9	8	7	6	5	4	3	2
Drill for body	5/16	9/32	17/64	15/64	2	10	17	19	26	28	30	36	39	44
Drill for threads	15/64	1	6	12	19	23	26	29	33	37	41	44	47	50

DATA ON LEATHER FILLETS

No.	1	2	3	4	5	6	7	8	10	12	14	16
Size or radius	1/16	⅛	3/16	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1
Width of face	3/32	3/16	5/16	⅜	½	9/16	21/32	¾	21/32	1 5/32	1⅜	1 9/16

SECTION IV

NONFERROUS METALS AND ALLOYS

MANGANESE BRONZE C

Used for propellers and castings that must be strong and ductile, manganese bronze *C*, specified by the Philadelphia navy yard, has the following analysis:

	Per cent
Copper	56.00
Zinc	37.00
Ferromanganese, 80 per cent	4.00
Aluminum	1.25
Norway iron	1.75

This alloy is unlike ordinary manganese bronze because of the absence of tin and the high content of iron, manganese and aluminum. It is a difficult alloy to mix unless the exact method of making the *hardener* is known. This hardener is different than the one employed in producing ordinary manganese bronze, but can be made satisfactorily by melting 25 pounds of copper under a cover of charcoal; when very hot, add 2½ pounds of iron in the form of thin sheet clippings, such as stove pipe iron, and stir thoroughly to dissolve the iron. Charge the iron loosely in small pieces to prevent fusion and when melted add the aluminum, and stir again. When the copper and iron have attained a high temperature, charge the additional 24 pounds of the 49-pound charge. When this copper has been melted, add 10 pounds of B grade manganese copper; melt and add 37 pounds of zinc. Stir thoroughly, remove from the furnace and pour into ingots.

For making the castings, melt the ingots and add 1.5 per cent of zinc to compensate for volatilization. Use heavy feeders, gate from the bottom, and do not shake-out the castings until they have cooled to their natural bright, greenish yellow color.

The pouring temperature is from 1790 degrees to 1810 degrees Fahr.

PHOSPHOR BRONZE

The term phosphor bronze is rather vague, as it is applied to a large number of alloys of widely different compositions. When used for the purposes of a bearing it contains a considerable percentage of lead. A good example of a phosphor bronze bearing alloy follows:

	Per Cent
Copper	81
Phosphor-copper (15 per cent)	3
Tin	7
Lead	9

Melt the copper under charcoal and when thoroughly liquid add the phosphor-copper; allow the metal to stand a few minutes with the furnace cover partially removed, then add the tin, and lastly the lead, stirring vigorously. The idea was prevalent at one time that by the use of phosphorus in bronze a large quantity of lead could be retained. This is erroneous, as phosphorus will cause the lead to separate in highly leaded mixtures. Of late there has been a tendency to confine the term phosphor bronze to the strongest grades of copper-tin alloys, thus indicating by the use of this name that a bronze is required possessing the highest physical properties possible in a copper-tin alloy. The formula for such an alloy follows:

	Pounds
Copper	90
Tin	5
Phosphor-tin (5 per cent)	5

The tensile strength of this alloy, when properly made, will vary from 39,000 pounds to 40,500 pounds per square inch. This variation may be due to several causes, such as the brand of copper used and the care with which it is melted.

It will be found expedient to use crucible rings when melting the copper. This will permit all of the ingots to be loosely charged at one time and the ring will protect the projecting ingots from the furnace gases. A little salt is also added when the copper becomes red, and as it sinks, charcoal should be liberally used so that the surface of the metal is always under cover. When melted, add the phosphor-tin first with thorough stirring, then, just before removal from the fire, add the block tin.

PARSON'S MANGANESE BRONZE

In producing Parson's manganese bronze, the following alloy, used as a *hardener,* first is made:

	Pounds
Norway iron clippings	36
Ground 80 per cent ferromanganese	8
Tin	20

A furnace capable of attaining a high temperature is required to melt the *hardener* alloy. The iron and ferromanganese must be liquified together, when the tin is added. In some cases the tin first is melted and poured into the liquid iron and manganese, but it is preferable to add the tin gradually in the solid form. This alloy should be run into thin strips, to facilitate making the small weights required. It is frequently shotted, but this should never be attempted without further equipment, as it is a dangerous operation.

For Parson's bronze, melt the following in the proportions given:

	Pounds
Copper	56.00
Zinc	41.50
Hardener	2.50
Aluminum	0.50

Melt the copper first; add the hardener; superheat a few minutes; stir thoroughly; add the aluminum and cool the metal with bronze from previous heats. If none is on hand, reserve a small amount of copper for this purpose; cool until the metal while nicely liquid, is not what would be considered hot; then commence to add the zinc, charging a little at a time at first and adding it finally as rapidly as the alloy will dissolve it without becoming chilled. When the zinc addition has been made, stir thoroughly, do not superheat, but pour into ingots. Metal with high elongation is accomplished by melting again.

The analysis should be approximately as follows:

	Per cent
Copper	57.10
Zinc	40.50
Iron	1.20
Tin	0.70
Manganese	0.10
Aluminum	0.40

BRONZE FOR MACHINERY CASTINGS

The general class of machinery castings may be taken to comprise all bronze parts used for engineering purposes that do not require a special alloy, and includes a multitude of castings of every imaginable shape and size, except those used for bearings or where great strength or other qualifications are demanded. For all purposes, where a good, reliable, easy-casting bronze is required, of a rich gold color, the following formula can be recommended:

	Pounds
Copper	88½
Tin	5½
Zinc	3½
Lead	2½

The copper is first melted under charcoal, then the zinc is added, next the tin, and lastly the lead, the metal being thoroughly stirred.

This alloy may be cheapened, if desired, by the addition of scrap metal, as for instance:

	Pounds	Ounces
Copper	66	6
Tin	4	2
Zinc	2	10
Lead	1	14
Scrap brass	25	

The scrap should be carefully selected if it is desired to produce an alloy of uniform quality, and should be of the same composition as the new metal. Consequently, scrap of unknown composition cannot be used in such cases. For the general run of castings, however, a little deviation is of no consequence. Therefore, purchased scrap may be used in any quantity up to 50 per cent of the mixture, the only care necessary being to select such pieces that experience has taught will be likely to be made of the same kind of bronze.

EFFECT OF VARIOUS ELEMENTS ON THE STRENGTH OF MANGANESE BRONZE

An investigation to ascertain the influence of the usual additions of tin, manganese aluminum and iron on brass of the following composition: Copper, 60 per cent, and zinc, 40 per cent, the proportions usually present in manganese-bronze, shows the following results:

Composition of Original Alloy

Copper 60; Zinc 40.

Impurity, Per Cent	Effect on Yield Point, Per Cent Increased	Effect on Maximum Stress, Per Cent Increased	Effect on Elongation, Per Cent Decreased
Tin			
1.1	19.0	11.0	61.0
2.13	33.0	4.0	83.0
Manganese			
1.16	11.9	12.3	25.5
2.07	11.9	12.3	improved
Aluminum			
1.06	increased	increased	73.0
1.9	89.0		89.0
Iron			
1.02	9.5	12.7	37.0

In making the alloys, the copper content of the 60-40 alloy was reduced by the amount of the tin, manganese, aluminum or iron that was added. All these elements increase the yield point and tensile strength, but reduce the elongation of the pure brass.

The Effect of Cadmium on Copper-Zinc Alloys

Researches recently conducted by Leon Guillet to determine the effect of using zinc containing cadmium for making brass gave the following results:

Up to 1 per cent of cadmium, no injurious effect can be noticed.

With more than 1 per cent of cadmium, the resilience of the brass is markedly lowered, but up to and under 2 per cent cadmium, the tensile strength is not injured.

RED BRASS FOR SMALL CASTINGS

For small castings that must be rapidly finished by automatic machines a free cutting metal of a good red color is required. These qualities are obtained by the use of lead instead of tin or zinc as the principal part of the alloy, thus producing an imitation gun metal that casts well, has a fine bronze color when cut, and makes clean, bright castings. A formula frequently used is as follows:

	Pounds
Copper	87
Lead	8
Zinc	2
Tin	3

Melt the copper under a cover of charcoal, then add the tin and zinc and lastly the lead, stirring thoroughly.

This alloy will be found very easy to machine and is extensively used for the manufacture of plumbers' red brass fittings. The addition of some other metal, such as zinc or tin, is necessary in copper and lead alloys, even when the proportion of lead is comparatively small, otherwise this metal will sweat out of the mixture and the castings will be marred by dark colored spots scattered over the surface, or the lead will ooze out in minute beads, which, when the castings are tumbled, batter up and produce very unsightly castings. The proportions of tin and zinc, given in the formula, will prevent this condition, and sometimes the zinc is increased to produce cheaper alloy, as in the following:

	Pounds
Copper	82
Lead	8
Zinc	8
Tin	2

These alloys, although very useful in their proper sphere, are not recommended for castings subjected to steam pressures.

YELLOW BRASS FOR SAND CASTINGS

While the proportions of zinc that can be used in making yellow brass is susceptible of wide variation between certain limits, it is not advisable to run above 30 per cent when good, clean yellow brass sand castings are desired. A good strong, freely cutting casting alloy is as follows:

	Pounds	Ounces
Copper	70	
Zinc	25	8
Tin	2	8
Lead	2	

First melt the copper under the usual cover of charcoal to a perfectly fluid condition, when the molten metal will appear clear and limpid. There must be no indications of mush or bubbling of the copper around the sides of the pot, but just a clear greenish orange surface. When this condition prevails, the zinc can be added without causing more than a slight hissing. Whenever the addition of the zinc is accompanied by a startling hissing noise, vivid light and much smoke, the copper has been overheated and burned, and the resulting metal will be of inferior quality and the losses high. Consequently, special care is necessary in melting the copper for yellow brass, and the zinc for the mixture should invariably be heated before being introduced into the copper. This may be accomplished by placing it on the furnace top, while the copper is being melted. It should be added to the molten copper in small pieces not more than 6 pounds in weight, and is lowered into the furnace with tongs and not thrown in, each piece being separately stirred to thoroughly incorporate the zinc and to avoid chilling the bath. After the zinc has been alloyed, the tin and lead are added, and should the metal prove too hard for the purpose for which it is intended, the quantity of tin can be diminished. When the addition of zinc is accompanied by the signs which indicate that the copper has been overheated, a deoxidizer should be used if high grade metal is required, and either iron or manganese is available for this purpose. If the former, use 1 per cent of yellow prussiate of potash. This should be wrapped in paper and lightly dropped upon the surface of the metal and allowed to remain until the water is driven off, the furnace being closed meanwhile. This may possibly take five minutes, when the potash is stirred in, the stirrer being cautiously inserted at first, to avoid possible danger of explosion.

Manganese may be introduced as manganese-copper in the proportion of one-fourth of a pound to 100 pounds of metal, and can be increased or decreased, as found necessary, to produce a pleasing brown color on the casting.

WHITE BRASS

True white brass is the alloy known as nickel silver, which is composed of copper and zinc, whitened by the addition of nickel, and possessing all the distinguishing features usually associated with brass, except the yellow color. As the term is at present understood, however, it applies to an alloy consisting largely of zinc and tin, which melts at a comparatively low temperature and for many years was known as white metal, but which has been greatly improved and modified in recent years, until it stands in a class by itself. It is much in demand for bearings for automobiles and as a lining metal for bearings. A formula that can be recommended follows:

	Pounds
Tin	55.50
Phosphor-tin	2.00
Antimony	1.50
Zinc	38.75
Copper	2.25

When preparing the alloy it will be found advisable to have the copper in the form of wire, sheets or ribbons, and to dissolve it in the zinc by melting a portion of the latter with the copper. Melt 20 pounds of zinc with the copper, and when it begins to flare, the copper will be dissolved. Stir well to be certain that the copper is dissolved, then gradually add the balance of the zinc, so as not to chill the molten metal. When all the zinc is melted add the antimony and a small piece of aluminum wire, possibly ¼ ounce, then add the tin and lastly the phosphor-tin, and pour into ingots.

MIXTURES FOR PLUMBERS' BRASS GOODS

Considerable variation exists in alloys used for plumbing goods, yellow brass being adopted by some makers and red alloys by others. The predominating idea is to get a mixture as cheap as possible, and to this end scrap metals are largely favored. A mixture that gives good results on high pressure work (not steam) follows:

Sheet brass clippings	71½	pounds
Copper wire	25	pounds
Lead	2	pounds
Tin	1	pound
Phosphor-copper (15 per cent)	8	ounces

The copper wire should be charged first, and when it begins to sink down a worn-out dry battery is thrown in, with a small shovelful of charcoal. The copper is then allowed to melt and the phosphor-copper added; the clippings are then charged, and it is advisable at this stage to place a ring on the crucible to increase its height, so that a larger quantity of clippings can be packed in, each time. When the clippings become red, they must be pushed down into the molten copper, and this is repeated until the entire charge is melted. The tin is next added and lastly the lead. The metal will smoke considerably, and should be poured when it has ceased to boil, or to impart vibrations to the skimmer. It will still smoke, but the surface of the brass can be seen by blowing the smoke away, and should appear bright. When pouring the molds, the metal should be rushed in quickly, and with decision, otherwise the castings will be smoky.

CHEAP BRASS MIXTURES

IMITATION MANGANESE BRONZE

	Pounds
Copper	59.00
Zinc	40.00
Aluminum	5 ounces
Tin	5 ounces
Tin plate clippings	6 ounces

First melt the copper under charcoal; when hot, add the tin plate loosely rolled; stir, add the aluminum, stirring again, and introduce the zinc in small pieces; when thoroughly incorporated, add the tin. If an easy cutting metal is desired, add several pounds of lead to this alloy in place of an equal amount of zinc.

CHEAP YELLOW BRASS

	Pounds
Copper	60.00
Zinc	36.00
Lead	4.00

CHEAP RED BRASS

	Pounds
Scrap copper wire	40.00
Zinc	7.50
Lead	7.50
Machinery brass scrap	45.00

Melt the scrap brass first and when hot, add the copper as rapidly as it can be dissolved; follow with the zinc and the lead. This makes a good, ordinary red metal.

CHEAP RED BRASS FROM ALL NEW METALS

	Pounds
Copper	83.00
Lead	8.50
Zinc	6.50
Tin	2.00

CHEAP BRASS MIXTURES
(Concluded)

A Tough Bending Alloy

	Pounds
Copper	84.50
Zinc	10.00
Lead	3.00
Tin	2.50

This alloy is suitable for trolley ears, splicers and other castings where a tough alloy that will bend without cracking is required. Melt the copper and add the zinc, lead and tin in the order named.

A Half Red and Half Yellow Alloy

	Pounds
Copper	55.00
Zinc	10.00
Lead	5.00
Yellow brass scrap	30.00

When the copper nears the melting point, add the yellow brass scrap and run down together; then add the zinc and the lead. This alloy has been used extensively for sprinkling wagon castings. The castings come out of the sand having a rich red color externally, but when cut, are yellow inside.

Seal Metal No. 1

	Pounds
Copper	80.00
Zinc	7.50
Lead	7.50
Tin	5.00

Seal Metal No. 2

	Pounds
Copper	76.50
Zinc	9.50
Lead	9.50
Tin	4.50

WEIGHTS OF ALLOYS AND METALS

Per Cubic Foot and Per Cubic Inch

	Wt. per cu. ft.	Wt. per cu. in.
Aluminum	166.5	0.0963
Alum. and tin, Al. 91, Sn. 9	178	0.103
Alum., copper and tin, Al. 85, Cu. 7.5, Sn. 7.9	188	0.109
Alum., cop. and tin, Al. 6.25, Cu. 87.5, Sn. 6.25	459	0.266
Alum., copper and tin, Al. 5, Cu. 5, Sn. 90	425	0.244
Aluminum, Al, 75.7, Cu. 3	187	0.1082
Cop., zinc and manganese, Zn. 20, Mn. 1.3	...	......
Antimony	421.6	0.2439
Babbitt's alloy	454	0.263
Bismuth	612.4	0.3544
Brass, Cu. 80, Zn. 20	536.3	0.3103
Brass, Cu. 70, Zn. 30	523.8	0.3031
Brass, Cu. 67, Zn. 33	522.7	0.3025
Brass, Cu. 60, Zn. 40	521.3	0.3017
Brass, Cu. 50, Zn. 50	511.4	0.2959
Brass, alum., 2 per cent alum	519	0.3000
Bronze, Cu. 95 to 80, Sn. 5 to 20	552	0.3195
Bronze, alum., 10 per cent al.	480	0.2775
Bronze, alum., 5 per cent al.	515	0.298
Bronze, phos	537	0.3095
Bronze, Tobin	503	0.291
Cadmium	539	0.3121
Chromium	436	0.254
Cobalt	533.1	0.3085
Copper	552	0.3195
Delta metal	527	0.305
German silver, Cu. 60, Zn. 20, Ni. 20	530	0.307
Gold, (pure, 1200.9 lbs. per cu. ft.)	1,150	0.665
Gun metal	544	0.315
Iridium	1,396	0.8076
Iron, cast	450	0.2604
Lead	709.7	0.4106
Lead and antimony, Pb. 30 Sb. 70	450	0.2604
Lead and antimony, Pb. 37, Sb. 63	460	0.266
Lead and antimony, Pb. 44, Sb. 56	475	0.275
Lead and antimony, Pb. 63, Sb. 37	514	0.2975
Lead and antimony, Pb. 83, Sb. 17	596	0.345
Lead and antimony, Pb. 90, Sb. 10	658	0.381
Lead & bismuth, Bi. 67, Pb. 33	639	0.370
Lead & bismuth, Bi. 50, Pb. 50	656	0.380
Lead & bismuth, Bi. 33, Pb. 67	682	0.395
Lead & bismuth, Bi. 25, Pb. 75	697	0.4035
Lead & bismuth, Bi. 17, Pb. 83	702	0.4065
Lead & bismuth, Bi. 12, Pb. 88	703	0.407
Manganese	499	0.289
Magnesium	109	0.063
Magnolia	650	0.376
Mercury	849	0.4915
Muntz metal, rolled	524	0.304
Nickel	548.7	0.3175
Osmium	1,402	0.812
Palladium	712	0.412
Partinium	178.8	0.1042
Platinum	1,347	0.7758
Platinum and iridium, Pt. 90, Ir. 10	1,347	0.7758
Rhodium	755	0.437
Ruthenium	765	0.443
Silver	655.1	0.3791
Steel, cast	489.6	0.2833
Tin	458.3	0.2652
Tin and antimony, Sn. 50, Sb. 50	424	0.2457
Tin and antimony, Sn. 75, Sb. 25	442	0.256
Tin and bismuth, Bi. 78, Sn. 22	587	0.340
Tin and bismuth, Bi. 63, Sn. 37	570	0.330
Tin and bismuth, Bi. 50, Sn. 50	546	0.316
Tin and bismuth, Bi. 37, Sn. 63	530	0.307
Tin and bismuth, Bi. 22, Sn. 78	504	0.292
Tin and lead, Sn. 97, Pb. 3	456	0.264
Tin and lead, Sn. 89, Pb. 11	475	0.275
Tin and lead, Sn. 80, Pb. 20	487	0.282
Tin and lead, Sn. 67, Pb. 33	512	0.297
Tin and lead, Sn. 50, Pb. 50	550	0.3185
Titanium	224	0.130
Tungsten	1,078.7	0.6243
Zinc	436.3	0.2525

DETERMINING SPECIFIC GRAVITY AND WEIGHTS OF ALLOYS

To find the approximate specific gravity of an alloy consisting of any two metals, use Ure's rule, which is as follows:

Multiply the sum of the weights into the product of the two specific gravity numbers for a numerator, and multiply each specific gravity number into the weight of the other body and add the products for a denominator. The quotient obtained by dividing the said numerator by the denominator is the truly computed mean specific gravity of the alloy.

$$M = \frac{(W + w)\ Pp}{Pw + Wp}$$

where M is mean specific gravity of alloy, W and w the weights, and P and p the specific gravity of the constituents.

To find the weight per cubic inch of an alloy, first find the sum of the quotients obtained by dividing the weight of each constituent metal by its weight per cubic inch. The weight of the alloy divided by this sum is the required weight per cubic inch of the alloy.

$$S = \frac{A}{a} + \frac{B}{b} + \frac{C}{c} + \frac{D}{d} + \frac{E}{e}$$

$$w = \frac{W}{S}$$

Where W = weight and w = weight per cubic inch of alloy.
A = weight and a = weight per cubic inch of one constituent.
B = weight and b = weight per cubic inch of another constituent, etc.

For example, take the alloy consisting of tin 74, antimony 18, copper 8. Taking W as 100 pounds, A (tin) = 74 pounds; B (antimony) = 18 pounds; C (copper) = 8 pounds, and a = 0.2652, b = 0.2439, c = 0.3195 (see page 165).

$$\text{Then } S = \frac{74}{0.2652} + \frac{18}{0.2439} + \frac{8}{0.3195} = 377.7 \text{ and } w = \frac{100}{377.7} = 0.265$$

Although the above give the correct mean calculated values, they should not be used unless the required information cannot be obtained from reliable sources, as the actual values vary slightly from these due to the contraction of some metals or expansion of others when alloyed.

DATA ON ALLOYS AND METALS

In the following table are given the weights, specific gravities and the melting points of various metals and alloys, with the chemical symbols as determined by various authorities:

Metal	Chemical symbol	Weight per cubic foot in pounds	Specific gravity	Melting point, deg. Fahr.
Aluminum, cast	Al	160	2.56	1,225
Aluminum bronze	...	475	7.68	1,908
Antimony	Sb	418	6.71	450
Babbitt metal	...	454	7.31	.....
Bell metal	...	501	8.06	1,782
Bismuth	Bi	617	9.90	516
Brass, cast	...	505	8.10	1,300
Bronze	...	534	8.56	1,890
Copper	Cu	554	8.60	1,929
Cadmium	Cd	536.85	8.64	612
Calcium	Ca	98.01	1.41	1,436
Nickel silver	...	516	....	1,940
Gun metal, 9 Cu, 1 Sn.	...	531	8.50	1,850
Iron, cast	...	450.08	7.2	1,967
Iron, wrought	Fe	476	7.55	2,732
Lead	Pb	712	11.419	618
Magnesium	Mg	108.62	1.74	1,200
Manganese	Mn	499.40	8.00	2,273
Mercury	Hg	849	13.596	Liquid
Nickel	Ni	516	8.67	2,642
Phosphor bronze	...	537	8.60	1,885
Platinum	Pt	1,342	21,522	3,227
Potassium	K	54.31	0.87	.....
Silver	Ag	655	10.505	1,733
Steel	...	489.6	7.854	2,687
Tin	Sn	462	7.409	450
Tobin bronze	...	523.06	8.379	1,340
Zinc	Zn	428	6.86	779

To convert the melting points from degrees Fahr. to degrees Cent., subtract 32, divide by 9 and multiply by 5.

BRASS AND BRONZE ALLOYS USED IN ENGLISH PRACTICE

Class of Service.	Copper, Lbs.	Tin, Lbs.	Zinc, Lbs.	Lead, Lbs.	Yellow Brass, Lbs.	15 Per Cent Phosphor-Copper, Lbs.
Bearings, heavy	84	14	2	0	0	0
Bearings, small	83	12	0	5	0	0
Bearings, engine	112	13	½	0	0	0
Bearings, heavy	160	25	5	0	0	0
Brass, common	112	0	56	0	0	0
Brass, dipping	112	0	36	0	0	0
Brass, coarse	112	0	56	10½	0	0
Copper flanges	112	0	14	0	0	0
Copper rivets	112	0	0	0	40	0
Coppersmith's solder	112	0	20	0	0	0
Clock metal	112	10	0	10	0	0
Condenser linings	112	7	28	7	0	0
Gilding metal	56	0	0	0	42	0
Marine engines	112	10½	10½	0	0	0
Muntries mixture	112	0	20	0	0	0
Pistons	112	14	0	0	14	0
Piston rings	87	10	0	0	0	3
White metal	12	64	168	0	0	0
Hydraulic metal	112	12	0	0	28	0
Phosphor bronze	112	12	0	0	0	6
Soft bronze	112	7	6½	4½	0	0
Red metal	112	5	12	4	0	½

TIN-ANTIMONY-COPPER ALLOYS

Alloys of tin, antimony and copper are used extensively as bearing metal, Britannia metal, etc. Analyses show that the tin usually exceeds 70 per cent; antimony is less than 20 per cent, and copper is less than 10 per cent. A large number of these alloys, obtained from various sources, are given in the accompanying table.

COMPOSITION OF TIN-ANTIMONY-COPPER ALLOYS

Name of metal	Tin, per cent	Antimony, per cent	Copper, per cent	Per cent
English Britannia	94	5	1	....
Bearing	91	4.5	4.5	....
English Britannia, sheet	90.6	7.8	1.5	....
English Britannia, cast	90.6	9.2	0.2	....
Bearing	90	6	4	....
Bearing, Russian R. R.	90	8	2	....
English Britannia	90	6	2	Bismuth, 2
English Britannia	90	7	3	....
Bearing	89.3	8.9	1.8	....
Pewter	89.3	7	1.8	Lead, 1.8
Bearing	88.9	7.4	3.7	....
Bearing	88.8	7.5	3.7	....
Queen's metal	88.5	7.1	3.5	Zinc, 0.9
Queen's metal	88.5	7	3.5	Bismuth, 1
Bearing	87	7	6	....
English Britannia	85.5	9.7	1.8	Zinc, 3
Bearing, heavy	85	7.5	7.5	....
Jacoby metal	85	10	5	....
German Britannia	84	9	2	Zinc, 5
French, car bearings	83.3	11.1	5.5	....
Bearing	83.3	8.3	8.3	....
Bearing, German R. R.	83	11	6	....
Bearing, valve rods, etc.	82	10	8	....
Bearing, French R. R.	82	12	6	....
Britannia, Baumgartel	81.9	16.3	1.8	....
Bearing, Swiss R. R.	80	10	10	....
Ashberry metal	80	14	2	Zinc, 1
Ashberry metal	79	15	3	Zinc, 2
Britannia, Ashberry	77.8	19.4	2.8	....
Britannia, Ashberry	77.9	19.4	....	Zinc, 2.8
Bearing, English	76.7	18.5	7.8	....
Bearing, German	76	17	7	....
Bearing	73	18	9	....
Bearing	72	26	2	....
German Britannia	72	24	4	....
Bearing, Karmarsch	71.4	7.2	21.4	....
Bearing, valve packing	71	24	5	....
Bearing, Karmarsch	70.7	19.7	9.5	....
Minofor, Britannia	68.5	18.2	3.3	Zinc, 10
Bearing, G. W. R., England	67	11	22	....
Bearing, French R. R.	67	22	11	....
Dewrance metal, locomotive	33.3	44.5	22.2	....

LEAD-TIN-ANTIMONY ALLOYS

The ternary alloys, in the accompanying table, are used extensively for bearing and type metals, as white metal for small castings, etc. A few alloys containing a small amount of copper are given for comparison. These alloys show that antimony never exceeds 25 per cent; lead varies from 5 to 93 per cent, and tin, from 1 to 75 per cent.

COMPOSITION OF LEAD-TIN-ANTIMONY ALLOYS

Name of metal	Lead, per cent	Tin, per cent	Antimony, per cent	Per cent
Electrotype metal	93	3	....	....
Bearing metal	86	1	....	....
Linotype metal	85	3	12	....
Bearing	83.3	8.3	8.3	....
Stereotype metal	82	6	12	....
Bearing	82	2	16	....
Stereotype	82	3.2	14.8	....
Bearing	80	10	10	....
Bearing, Compagnie de l'Est	80	12	8	....
Bearing	80	5	15	....
Bearing, like Glyco, etc.	80.5	4.5	14.5	Arsenic, 0.5
Bearing, like Magnolia	78	6	16	....
Bearing, Magnolia and Tandem	77.7	5.9	16.8	....
Type metal	77.5	6.5	16	....
Bearing, anti-friction	77	10	12.5	Copper, 0.5
Bearing, like Coleco	77	8	14	Copper, 1.0
Bearing	76	7	17	....
Metallic packing, Compagnie d'Orleans	76	14	10	....
Bearing, American R. R.	73.5	8	18.5	....
Piston packing, Compagnie du Nord	73	12	15	....
Bearing, French R. R.	70	20	10	....
Stereotype, Mackenzie metal	70	13	17	....
Bearing, Paris-Lyon-Mediterranee R. R.	70	10	20	....
Type	70	10	18	Copper, 2
Bearing, American R. R.	68	21	11	....
Bearing, graphite metal	68	15	17	....
Stereotype	68	17	18	....
Type	63.2	12	24	Copper, 0.8
Bearing	62.5	26.2	10	Copper, 1.3
Bearing	62	27	10	....
Type	60.5	14.5	24.2	Copper, 0.75
Type	60	35	5	....
Bearing	60	20	20	....
Type, common	60	10	30	....
Solder	60	39	1	....
Type	55.5	40	4.5	....
Type, best	50	25	25	....
Bearing	48	40	10	Copper, 2
Bearing, American R. R., No. 2	46	36.5	16.5	Copper, 1
Hoyle's metal	42	46	12	....
Bearing, Chemin de fer de l'Est Francais	42	42	16	....
Bearing	40	45	15	....
Bearing, German	40	42	26	Copper, 2
Bearing, Italian R. R.	37	38	25	....
Stereotype	35	60	5	....
White metal	33	53	10.6	Copper, 2.4
Bearing	10	75	15	....
Bearing	10	75	12	Copper, 3
For small castings	5	75	20	....

MISCELLANEOUS ALLOYS

ALLOYS	Antimony	Bismuth	Copper	Gold	Lead	Nickel	Silver	Tin	Zinc	Cadmium
Brass, common yellow	....	....	65	....	2	....	....	0	33..	..
Brass, naval rod mixture	....	....	62	....	....	....	....	1.5	36½	....
Brass castings, common	....	....	53	....	....	....	....	0	47	....
Brass castings, good yellow	....	....	75	....	2	....	....	2..	21	....
Gun metal	....	....	10	....	....	....	....	1	....	....
Copper flanges	....	....	9	....	....	....	....	0.26	1	....
Muntz metal	....	....	6	....	....	....	....	....	4	....
Bronze statuary	....	....	90	....	....	....	....	7	3	....
German silver	....	....	57	....	....	18	....	....	25	....
Britannia metal	8	....	2	....	....	....	....	90	....	....
Chinese white copper	....	....	20.2	....	....	15.8	....	1.3	12.7	....
Medals	....	....	100	....	....	....	....	....	8	....
Pattern letters	10	....	....	....	45	....	....	45	....	....
Pinchbeck	....	....	5	....	....	....	....	....	1	....
Babbitt metal	10	....	3	....	....	....	....	77	....	....
Bell metal	....	....	4	....	....	....	....	1	....	....
Chinese gongs	....	....	40.5	....	....	....	....	9.2	....	....
Metal to expand in cooling	16.7	8.3	....	....	75	....	....	....	....	....
Pewter	17	....		....	....	....	....	100	....	....
Type metal	12	....	....	....	83	....	....	5	....	....
Solders—										
Newton's, melts at 212 deg. F	....	8	....	....	5	....	....	3	....	....
Rose's, melts at 201 deg. F	....	2	....	....	1	....	....	1	....	....
Tin solder, coarse, at 500 deg. F	....	....	....	....	3	....	....	1	....	....
Tin solder, ordinary, at 360 deg. F	....	....	....	....	1	....	....	2	....	....
Tin solder, melts at 225 deg. F	....	50.8	....	....	27.8	....	....	21.4	....	....
Brazing, hardest	....	....	3	....	....	....	....	....	1	....
Brazing, hard	....	....	1	....	....	....	....	....	1	....
Brazing, soft	....	....	4	....	....	....	....	1	3	....
Brazing, softest	1	....	....	....	....	....	....	2	....	....
Copper to copper	....	....	55	....	....	....	....	5	40	....
Copper to iron	....	....	80	....	....	....	....	4	16	....
Iron solder	....	....	2	....	....	....	....	....	1	....
Steel solder	....	....	3	....	....	....	19	....	1	....
Fine brass work	....	....	8	....	....	....	1	....	8	....
Pewter solder, ordinary	....	....	....	....	1	....	....	2	....	....
Pewter solder, soft	....	2	....	....	4	....	....	3	....	....
Lead solder	....	....	....	....	33.0	....	....	16	....	....
Gold solder	....	....	1	24	....	....	2	....	....	....
Silver solder, hard	....	....	1	....	....	....	4	....	....	....
Silver solder, soft	....	....	....	....	....	....	2	....	....	....

COPPER-TIN-PHOSPHORUS ALLOYS

Bearing Alloy

	Pounds	Ounces
Copper	80	4
Tin	14	8
Fifteen per cent phosphor copper	5	4

The physical properties of this alloy are given as follows:

Tensile strength, pounds per square inch	17,000
Elongation, per cent in 2 inches	1.0

Remarks:—A hard and brittle alloy, likely to break in service unless supported by a backing of tougher metal.

Piston Packing Rings

	Pounds	Ounces
Copper	81	4
Tin	10	12
Zinc	3	0
Fifteen per cent phosphor copper	5	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	19,000
Elongation in 2 inches, per cent	3.0

Remarks:—The greater ductility that would have been obtained by decreasing the tin, has been largely offset by the addition of zinc. The result, however, is a stronger and more ductile alloy than the first mentioned alloy.

Gear Wheels

	Pounds	Ounces
Copper	88	1
Tin	12	3
Fifteen per cent phosphor copper	9	12

The physical properties of this alloy are:

Tensile strength, pounds per square inch	30,000
Elongation per cent in 2 inches	4.5

COPPER-TIN-PHOSPHORUS ALLOYS
(*Continued*)

Gear Wheels

	Pounds	Ounces
Copper	87	8
Tin	12	0
Fifteen per cent phosphor copper	10	8

The physical properties of this alloy are:

Tensile strength, pounds per square inch	31,000
Elongation, per cent in two inches	7.0

Piston Packing Rings

	Pounds	Ounces
Copper	82	13
Tin	10	11
Fifteen per cent phosphor copper	6	8

The physical properties of this alloy are:

Tensile strength, pounds per square inch	52,000
Elongation, per cent in 2 inches	6.0

Bearings

	Pounds	Ounces
Copper	84	5
Tin	10	3
Fifteen per cent phosphor copper	5	8

The physical properties of this alloy are:

Tensile strength, pounds per square inch	42,000
Elongation, per cent in 2 inches	10.0

Bushings

	Pounds	Ounces
Copper	84	7
Tin	10	5
Fifteen per cent phosphor copper	5	4

The physical properties of this alloy are:

Tensile strength, pounds per square inch	42,000
Elongation, per cent in 2 inches	12.0

COPPER-TIN-PHOSPHORUS ALLOYS

(Continued)

Ordinary Castings

	Pounds	Ounces
Copper	85	13
Tin	10	3
Fifteen per cent phosphor copper	5	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	37,000
Elongation, per cent in 2 inches	11.0

Bearings

	Pounds	Ounces
Copper	85	6
Tin	9	6
Fifteen per cent phosphor copper	5	4

The physical properties of this alloy are:

Tensile strength, pounds per square inch	45,000
Elongation, per cent in 2 inches	12.0

Bearings

	Pounds	Ounces
Copper	85	7
Tin	9	9
Fifteen per cent phosphor copper	5	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	45,000
Elongation, per cent in 2 inches	15.0

Bearings

	Pounds	Ounces
Copper	85	0
Tin	10	0
Fifteen per cent phosphor copper	5	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	40,000
Elongation in 2 inches	11.0

COPPER-TIN-PHOSPHORUS ALLOYS
(Continued)

Sheaves

	Pounds	Ounces
Copper	86	0
Tin	9	0
Fifteen per cent phosphor tin	5	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	43,000
Elongation, per cent in 2 inches	25

Worm Gear Blanks

	Pounds	Ounces
Copper	88	8
Tin	5	0
Fifteen per cent phosphor copper	6	8

The physical properties of this alloy are:

Tensile strength, pounds per square inch	56,000
Elongation, per cent in 2 inches	28.0

Worm Gear Blanks

	Pounds	Ounces
Copper	88	11
Tin	4	13
Fifteen per cent phosphor copper	6	8

The physical properties of this alloy are:

Tensile strength, pounds per square inch	55,000
Elongation, per cent in 2 inches	36.0

Worm Gear Blanks

	Pounds	Ounces
Copper	88	8
Tin	5	0
Fifteen per cent phosphor copper	6	8

The physical properties of this alloy are:

Tensile strength, pounds per square inch	55,000
Elongation, per cent in 2 inches	34.0

COPPER-TIN-PHOSPHORUS ALLOYS
(Continued)

WORM GEAR BLANKS

	Pounds	Ounces
Copper	90	0
Tin	4	0
Fifteen per cent phosphor copper	6	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	51,000
Elongation, per cent in 2 inches	43.0

PINIONS

	Pounds	Ounces
Copper	87	5
Tin	8	15
Fifteen per cent phosphor copper	3	12

The physical properties of this alloy are:

Tensile strength, pounds per square inch	41,000
Elongation, per cent in 5 inches	22.0

WORM GEAR BLANKS

	Pounds	Ounces
Copper	88	3
Tin	9	13
Fifteen per cent phosphor copper	2	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	55,000
Elongation, per cent in 2 inches	54.0

SHEAVES

	Pounds	Ounces
Copper	89	13
Tin	7	3
Fifteen per cent phosphor copper	3	0

The physical properties of this alloy are:

Tensile strength, pounds per square inch	55,000
Elongation, per cent in 2 inches	50.0

COPPER-TIN-PHOSPHORUS ALLOYS
(*Concluded*)

Gun Metal

	Pounds	Ounces
Copper	86	9
Tin	11	13
Zinc	1	9.5
Fifteen per cent phosphor copper	0	0.5

The physical properties of this alloy are:

Tensile strength, pounds per square inch	44,000
Elongation, per cent in 2 inches	21.0
Reduction of area, per cent	20.0

Gun Metal

	Pounds	Ounces
Copper	86	9
Tin	11	6½
Zinc	2	0
Fifteen per cent phosphor copper	0	0½

The physical properties of this alloy are:

Tensile strength, pounds per square inch	45,000
Elongation, per cent in 2 inches	20.0
Reduction of area, per cent	23.0

Gun Metal

	Pounds	Ounces
Copper	86	8½
Tin	11	12
Zinc	1	11
Fifteen per cent phosphor copper	0	0½

The physical properties of this alloy are:

Tensile strength, pounds per square inch	46,000
Elongation, per cent in 2 inches	25.0
Reduction of area, per cent	25.0

PHOSPHOR BRONZE ALLOYS

No.	Character of Sample	Copper, Per cent	Tin, Per cent	Zinc, Per cent	Phosphorus, Per cent
1	Bearings	84.50	14.50	nil	0.86
2	Piston packing ring	85.60	10.85	2.74	0.82
3	Gear Wheels	86.80	12.20	trace	1.43
4	Gear Wheels	87.00	12.00	trace	1.56
5	Piston packing ring	87.70	10.70	nil	0.97
6	Bearings	88.90	10.15	nil	0.82
7	Bushings	88.90	10.30	nil	0.77
8	Castings	89.00	10.00	nil	0.71
9	Bearings	89.70	9.40	nil	0.78
10	Bearings	89.20	9.60	nil	0.71
11	Bearings	89.10	10.10	nil	0.72
12	Sheaves	90.40	8.96	nil	0.73
13	Worm Wheel Rim	94.20	4.90	nil	0.96
14	Worm Wheel Rim	94.40	4.80	nil	0.98
15	Worm Wheel Rim	95.50	4.95	nil	0.95
16	Worm Wheel Rim	95.20	3.82	nil	0.86

The above alloys have the following physical properties:

No.	Tensile strength, pounds per square inch	Elongation, per cent in 2 inches
1	17,382	1.0
2	19,040	3.0
3	30,000	4.5
4	31,225	7.0
5	51,968	6.0
6	41,112	10.0
7	42,560	12.00
8	36,736	11.0
9	45,248	12.0
10	45,224	15.0
11	40,444	11.0
12	44,500	25.0
13	56,000	28.0
14	55,552	36.0
15	55,000	34.0
16	51,296	43.0

COMPOSITIONS OF MISCELLANEOUS ALLOYS

Damar Bronze

This alloy is used as a bearing metal, the composition being approximately as follows:

	Per cent
Copper	76.50
Tin	11.00
Lead	12.50

Graney Bronze

This alloy also is used for making bearings. Its composition follows:

	Per cent
Copper	75.50
Tin	9.50
Lead	15.00

Die-Casting Alloys (Bronze)

Analysis No. 1

	Per cent
Copper	79.26
Zinc	15.24
Aluminum	4.78
Manganese	0.16
Iron	0.56
Tin	Trace

Analysis No. 2

	Per cent
Copper	79.42
Zinc	16.00
Aluminum	3.85
Manganese	0.13
Iron	0.60

Analysis No. 3

	Per cent
Copper	89.88
Aluminum	10.06
Manganese	0.06

MISCELLANEOUS ALLOYS
(Continued)

ELECTRODE BRONZE

	Per cent
Copper	87.39
Tin	7.25
Manganese	0.18
Zinc	4.95

This bronze was used as the material of construction of bronze, water-cooled electrode holders for ferrosilicon furnaces. It is a good tough metal, suitable for many purposes where such an alloy is specified. The manganese content is somewhat higher than necessary. This should be represented by the addition of 0.5 per cent of 30 per cent manganese copper as the maximum.

KOCHLIN'S BEARING ALLOY

	Per cent
Copper	90
Tin	10

This alloy is usually deoxidized with phosphorus, using 0.25 per cent of phosphor copper.

LAFOND'S HEAVY FRICTION METAL

	Per cent
Copper	83.00
Tin	15.00
Lead	0.50
Zinc	1.50

HARRINGTON BRONZE

	Per cent
Copper	57.00
Zinc	41.00
Tin	1.00
Iron	0.75
Aluminum	0.25

This alloy somewhat resembles manganese bronze, but is deficient in elongation. It may be used for unimportant castings where cheap metal is specified.

MISCELLANEOUS ALLOYS
(*Continued*)

Typewriter Metal

	Per cent
Copper	57
Nickel	20
Aluminum	3
Zinc	20

Place the nickel in the bottom of the crucible with copper on top; use charcoal and borax as a flux; when molten, add the aluminum and if too hot, cool before adding the zinc. Used for typewriter parts.

Kern's Silicon Hydraulic Bronze

	Per cent
Copper	76.75
Yellow brass clippings	10.00
Tin	12.00
Zinc	1.25
Silicon copper	2 ounces

We do not recommend the use of silicon copper as a deoxidizer in bronze, when the latter contains lead.

Geage's Alloy

	Per cent
Copper	60.00
Zinc	38.50
Iron	1.50

Geage's alloy is one of the iron brasses that has been supplanted largely by the advent of manganese bronze.

Non-Gran

	Per cent
Copper	87
Tin	11
Zinc	2

The analysis of this metal showed a small amount of lead and iron; the former probably was an impurity of the zinc and the latter, a deoxidizing agent.

MISCELLANEOUS ALLOYS
(Continued)

Argentan

	Per cent
Copper	52
Nickel	26
Zinc	22

Argentan is a nickel silver designed for use as an imitation silver.

Needle Metal

	Per cent
Copper	84.50
Lead	2,00
Tin	8.00
Zinc	5.50
15 per cent phosphor copper	2 ounces

Place the phosphor copper in the bottom of the pot and charge the copper on top; cover well with charcoal and melt. Needle metal is so called because it is supposed to be sufficiently fluid to run needles.

Japanese Bronze

	Per cent
Copper	83
Lead	10
Tin	5
Zinc	2

Japanese bronze is a free-cutting alloy, and as such is useful for red brass castings that are to be rapidly machined.

Mira Metal (Original Analysis)

	Per cent
Copper	74.76
Zinc	0.62
Lead	16.35
Tin	0.91
Iron	0.43
Nickel and cobalt	0.24
Antimony	6.69

This alloy is claimed to be acid-resistant and for that reason is suitable for making castings that are exposed to the action of acid liquors. Why this should be is not stated. The alloy is too brittle to be of any use and the proper mixture follows:

	Per cent
Copper	74.25
Lead	16.50
Tin	8.00
Nickel	1.00
15 Per cent phosphor copper	0.25

Antimony, zinc, iron and cobalt are omitted.

Place the phosphor copper in the bottom of the pot; charge the copper on top and melt together with the 1 per cent nickel; then add the tin, cool to pouring temperature and charge the lead.

MISCELLANEOUS ALLOYS
(*Continued*)

Acid Resisting Alloy

Irmann's alloy for resisting hot, concentrated sulphuric acid, may be made as follows:

	Per cent
Copper	41
Nickel	50
70 per cent ferrotungsten	6
10 per cent aluminum bronze	2
30 per cent manganese copper	1

Melt the copper and the nickel together under a flux of fluorspar with a little lime and when thoroughly liquid, add the forrotungsten in a pulverized form; stir thoroughly, add the aluminum bronze and the manganese copper. A high temperature is required to make the alloy.

Nergandin Alloy

This alloy is used for condenser tubing as it is highly resistant to corrosion. The alloy follows:

	Per cent
Copper	70
Zinc	28
Lead	2

Melt the copper under plenty of charcoal, add the zinc gradually and charge the lead last.

A Good General Acid Bronze

	Per cent
Copper	85.25
Tin	9.25
Lead	4.50
15 per cent phosphor copper	1.00

Melt the copper under charcoal, add the phosphor copper, allow the mixture to stand for 5 minutes, then add the tin and the lead.

MISCELLANEOUS ALLOYS
(Continued)

HYDRAULIC METAL

Guillet's hydraulic metal consists of the following metals:

	Per cent
Copper	82.00
Tin	8
Zinc	5
Lead	3
Manganese	2

The manganese is added in the form of metallic manganese or as 30 per cent manganese copper. With 2 per cent manganese, however, the alloy is liable to be difficult to run. In practice, the manganese should be reduced to the addition of 0.5 per cent of 30 per cent manganese copper.

HIGH PRESSURE BRONZE

	Per cent
Copper	82.00
Tin	7.50
Zinc	5.00
Lead	5.50

ANOTHER HIGH PRESSURE BRONZE

	Per cent
Copper	90
Tin	6
5 per cent phosphor tin	4

BRONZE TO WITHSTAND HIGH PRESSURE CARBON DIOXIDE

	Per cent
Copper	80.00
Tin	7.50
Zinc	12.50

HYDRAULIC BRONZE

	Per cent
Copper	85
Tin	11
Yellow brass clippings	4

MISCELLANEOUS ALLOYS
(Continued)

Baily's Metal

	Per cent
Copper	82.00
Tin	13.00
Zinc	5.00

Baily's metal is the alloy used in making the standard yard measure of the United States, also the standard imperial yard of Great Britain, and for 50 copies of this yard for the use of various foreign governments.

Blanched Copper

	Per cent
Copper	91.00
White arsenic	9.00

This alloy used to be made by arranging copper turnings in alternate layers with the white arsenic and charcoal in a crucible, then fusing the charge. It is better made by the addition of metallic arsenic to molten copper. The alloy is used for clock dials and scales for thermometers and barometers.

Ancient Statuary

An analysis of a statute of Budha supposed to be 3500 years old divulged the following composition:

	Per cent
Copper	91.502
Iron	7.591
Silver	0.021
Arsenic	0.079
Sulphur	0.510
Gold	0.0005
Insoluble	0.292

The metal was simply a ferrous copper high in sulphur.

Aterite

Aterite is used as an acid-resisting metal, largely for the production of valves. One analysis of a casting alloy gave the following:

	Per cent
Copper	65.00
Nickel	9.00
Zinc	20.00
Iron	4.00
Lead	2.00

MISCELLANEOUS ALLOYS
(Concluded)

The following alloys are well adapted for the requirements of electric railway service.

Bearing Metal

New Metal Mixture	Pounds	*New Metal and Scrap Mixture*	Pounds
Copper	77	Copper	38½
Tin	8	Tin	4
Lead	15	Lead	7½
		Scrap	50

Maximum impurities allowed, 1 per cent. No. 1 Bearing Metal is used for axle, journal and motor bearings, check plates, etc.

Bronze

New Metal Mixture	Per cent	*New Metal and Scrap Mixture*	Per cent
Copper	88.40	Copper	62.00
Tin	5.50	Tin	3.80
Lead	2.80	Lead	1.90
Zinc	3.30	Zinc	2.30
		Scrap	30.00

Maximum impurities allowed, 1.5 per cent. No. 2 Bronze is used for trolley wheels, car trimmings, trolley harps, and such power house castings as key heads, glands, keeper hooks, pump valves, oil and grease cups and all castings except bearings.

Bell Metal

	Pounds
Copper	82
Tin	18

Maximum impurity allowed, 1.5 per cent. This alloy is made of all new metals, no scrap being specified. Its use is confined to signal bells.

Steam Metal

New Metal Mixture	Pounds	*New Metal and Scrap Mixture*	Pounds
Copper	85	Copper	59½
Tin	5	Tin	3½
Lead	5	Lead	3½
Zinc	5	Zinc	3½
		Scrap	30

Maximum impurities allowed, 1.5 per cent. This alloy is used for all castings for steam fittings.

Common Brass

	Pounds
Copper	67
Zinc	33

Scrap, up to 100 per cent.

Maximum impurities allowed, 1.5 per cent. Common brass is used for miscellaneous castings, such as the various meter and controller parts.

All scrap must be of the same composition as the alloy with which it is to be mixed, and where the amount of scrap specified cannot be obtained, new metals must be used alone.

ALLOYS FOR U. S. BUREAU OF STEAM ENGINEERING

The following specifications for the composition of nonferrous alloys were issued by the United States bureau of steam engineering.

Specifications for Casting Materials

The composition must be made of such materials as will give the required chemical analysis. Scrap will not be used except such as may result from the process of manufacture of articles of similar composition.

Commercial Brass

	Per cent
Copper	64 to 68
Zinc	32 to 34
Iron	2.0*
Lead	3.0*

Muntz Metal

	Per cent
Copper	59 to 62
Zinc	39 to 41
Lead	0.6*

Brazing Metal

	Per cent
Copper	84 to 86
Zinc	14 to 16
Iron	0.06*
Lead	0.30*

Gun Bronze

	Per cent
Copper	87 to 89
Tin	9 to 11
Zinc	1 to 3
Iron	0.06*
Lead	0.30*

Journal Bronze

	Per cent
Copper	82 to 84
Tin	12.5 to 14.5
Zinc	2.5 to 4.5
Iron	0.06*
Lead	1.00*

*Maximum.

STATUARY BRONZE

Many different alloys are known as statuary bronze, some of which incline more to the nature of yellow brass than bronze, as they contain a considerable percentage of zinc. The alloy, however, which seems to possess the greatest claim to be considered standard, is as follows:

	Pounds
Copper	90
Tin	7
Zinc	3

The addition of 8 ounces of lead to every 100 pounds of this alloy is frequently made to facilitate machining.

Another alloy, frequently used on United States government work, is as follows:

	Pounds
Copper	90
Tin	5
Zinc	5

To every 100 pounds, add 8 ounces of lead.

An alloy, which is also considered standard and is frequently used in casting tablets, is as follows:

	Pounds	Ounces
Copper	90	
Zinc	7	8
Tin	2	8

A tablet alloy which is more expensive, but not so liable to produce smoky castings, follows:

	Pounds	Ounces
Copper	88	..
Tin	6	..
Zinc	3	8
Lead	2	8

For a light colored alloy, the following is sometimes used:

	Pounds
Copper	79
Zinc	20
Tin	1

As the latter is really a yellow brass, it will be found more suitable for light, thin castings, than for heavier sections, as less difficulty will be experienced with heavy castings if either of the two alloys, first given, are used.

STATUARY BRONZE
(Continued)

The statue of Germanicus in Potsdam, Germany, consists of the following alloy:

	Per cent
Copper	89.78
Tin	6.16
Zinc	2.35
Lead	1.33
Nickel	0.27

The statue of Bacchus also at Pottsdam follows:

	Per cent
Copper	89.34
Tin	7.50
Zinc	1.63
Lead	1.21
Iron	0.18

The statue of The Shepard, also at Pottsdam contains a little more tin as follows:

	Per cent
Copper	88.68
Tin	9.20
Zinc	1.28
Lead	0.77

A statue of the Great Elector erected in Berlin, Germany, in 1703 was made of the following rather complex alloy:

	Per cent
Copper	89.09
Tin	5.82
Zinc	1.64
Lead	2.62
Iron	0.13
Nickel	0.11
Antimony	0.60

The sculptor Glabenbeck used a very soft alloy. His statues of Melanchthon at Wittenberg, and of William IV at Cologne were made of the following alloy:

	Per cent
Copper	89.55
Tin	2.99
Zinc	7.46

It is evident the individual preferences of the sculptor has had a great influence in determining the alloy to be used for his work.

STATUARY BRONZE
(Concluded)

An analysis of the statue of Henry IV, Paris, France, showed it to consist of the following alloy:

	Per cent
Copper	91.40
Tin	3.75
Zinc	4.20
Lead	0.48

An analysis of the statue of Napoleon I, Paris, follows:

	Per cent
Copper	75.00
Tin	3.00
Zinc	20.00
Lead	2.00

It will be noted the Napoleon statue was cast of a good grade of yellow brass. This alloy is excellent for producing castings that are required to be of a yellowish color when finished, and is easier to cast than ordinary yellow metal.

The Column Vendome, Paris, consists of a copper-tin alloy as follows:

	Per cent
Copper	89.20
Tin	10.20
Zinc	0.50
Lead	0.10

The above was the old Vendome Column which was made by recasting captured cannon.

An equestrian statue of Louis XIV, cast by Keller in 1699 had the following composition:

	Per cent
Copper	91.40
Tin	1.70
Zinc	5.35
Lead	1.37

This alloy is very soft, in which respect it differs greatly from an equestrian statue of Louis XV, the composition of which follows:

	Per cent
Copper	82.45
Tin	10.30
Zinc	4.10
Lead	3.15

PATENTED NONFERROUS ALLOYS

Manganese Bronze

A method of making manganese bronze using a special hardener was patented in Great Britain by F. Heusler and the British Mining & Metal Co. The specifications cover an alloy containing from 15 to 20 per cent manganese; 5 to 15 per cent aluminum, and small quantities of lead, tin, nickel, cobalt chronium and other metals. The following alloy is preferred for the hardener:

	Per cent
Copper	63.00
Manganese	25.00
Aluminum	10.00
Iron	2.00

The manganese bronze is made as follows:

	Per cent
Copper	54.00
Hardener	6.00
Zinc	40.00

The finished manganese bronze would have approximately the following analysis:

	Per cent
Copper	57.78
Zinc	40.00
Manganese	1.50
Aluminum	0.60
Iron	0.12

In making the alloy it would be necessary to allow about 1.5 per cent excess zinc to compensate for volatilization, also in remelting further additions would have to be made. The manganese, aluminum and iron would be diminished by oxidation in making the alloy.

The above patent also specifies an alloy for bearings. In this alloy the manganese bronze hardener is used as a deoxidizer. The bearing alloy follows:

	Per cent
Copper	83.00
Tin	9.00
Zinc	6.00
Hardener	2.00

PATENTED NONFERROUS ALLOYS
(Concluded)

Aluminum-Manganese Bronze

The addition of manganese to aluminum bronze has been the subject of patents in most civilized countries. In Austria, F. Teltscher was awarded a patent on the following alloy:

	Per cent
Copper	88.16
Aluminum	10.00
Manganese	1.20
Zinc	0.64

Imitation Silver

Alloys having a silvery appearance afford a fertile field for inventors. The following example was patented in Great Britain by C. E. Monkhouse and M. H. Denton:

	Per cent
Copper	69.50
Nickel	15.00
Zinc	8.50
Tin	4.50
Lead	2.50

Another alloy which looks like silver, and is said to have the added value of being noncorrosive, and which takes a high polish was patented by C. L. Jones in United States patent No. 1244742. The alloy follows:

	Per cent
Nickel	67.80
Copper	28.00
Manganese	2.50
Iron	1.50
Vanadium	0.02

Another noncorrosive alloy is the following. It is to be used for electrical contacts. The alloy which is expensive follows:

	Per cent
Platinum	45.00
Silver	25.00
Gold	15.00
Copper	15.00

The patent is United States No. 1101534 and the patentee R. B. Graf.

ALUMINUM ALLOYS

Strong Aluminum Alloys

The following alloy is used extensively in the manufacture of automobile pistons, aluminum worm wheels, and for all purposes requiring an alloy of more than the usual strength.

First make the following hardener:

Melt together under charcoal

	Pounds
Copper	10
Nickel	1¼

When thoroughly fluid, add 5 pounds of aluminum in small pieces, and while the alloy is at a high temperature, add 3¾ pounds of tin plate and stir vigorously with a thin iron bar until all the tin plate is dissolved. The alloy should be thoroughly fluid, that is, no lumps should be located by the stirring bar. At this stage, add gradually 10 pounds of aluminum, making a total of 15 pounds of this metal; thoroughly stir the bath and ingot.

To make the aluminum alloy, place a crucible of suitable size in the furnace and melt therein 83½ pounds of aluminum; allow it to attain a very dull red temperature, then add 6 pounds of the hardener, and ½ pound of magnesium; stir well to insure the thorough incorporation of the added metals; follow with an additional 10 pounds of aluminum, making a total of 93½ pounds of this metal, 6 pounds of hardener and ½ pound of magnesium. The resulting alloy then will approximate the following composition by analysis:

	Per cent
Aluminum	95.98
Copper	2.00
Nickel	0.24
Iron	1.00
Silicon	0.40
Magnesium	0.38

When carefully made this alloy should possess the following physical properties:

Ultimate strength, pounds per square inch	27,000 to 29,000
Yield point, pounds per square inch	12,000 to 14,000
Elongation in 2 inches, per cent	3.50 to 4.00
Reduction of area, per cent	4.00 to 5.00

ALUMINUM ALLOYS
(Continued)

Aluminum Alloys for Drawing Into Wire

Alloy A

	Per Cent
Aluminum	98.40
Copper	1.60

To make the alloy, melt together 96.80 per cent of pure aluminum and 3.20 per cent of an alloy composed of 50 per cent copper and 50 per cent of aluminum

Alloy B

	Per Cent
Aluminum	97.70
Copper	1.00
Nickel	1.30

In making alloy *B*, first make a hardener, as follows:

	Per Cent
Copper	20.00
Nickel	26.00
Aluminum	54.00

To make the alloy melt the following together:

	Per Cent
Aluminum	95.00
B hardener	5.00

Alloy C

	Per Cent
Aluminum	98.00
Manganese	2.00

In making alloy *C*, use the commercial alloy of manganese and aluminum which contains approximately 20 per cent of manganese and the balance aluminum. This is the safest method of making the alloy from the standpoint of the ordinary brassfounder.

Physical Properties

The physical properties of the foregoing alloys will be approximately as follows:

Alloy A

Electrical conductivity, 50 per cent of that of copper. Tensile strength, 39,000 pounds per square inch in wire.

Alloy B

Electrical conductivity, 49 per cent of that of copper. Tensile strength, 45,500 pounds per square inch in wire.

Alloy C

Electrical conductivity, 48 per cent of that of copper. Tensile strength, 35,000 pounds per square inch in wire.

ALUMINUM ALLOYS

(*Continued*)

Aluminum Alloys for Casting

One of the most extensively used alloys of aluminum is what is known as No. 12. It consists of aluminum and copper. The usual proportions are copper, 8 per cent and aluminum, 92 per cent, but it is not unusual for the alloy to be softened by reducing the percentage of copper to 7, and sometimes to 6 per cent, the aluminum being increased in proportion to the decrease in the percentage of copper.

The best method of making this alloy is by the use of a hardener composed of equal parts of copper and aluminum, as follows:

	Pounds
Copper	50
Aluminum	50

Melt the copper under a cover of fine charcoal, and when thoroughly liquid, add the aluminum gradually, in small pieces, and between additions, stir with an iron bar coated with alundum cement applied as a wash and afterwards dried. Have the stirrer hot before dipping into the molten metal. Add the aluminum no faster than the copper will dissolve it without being chilled partly solid, and after the addition of all the aluminum, remove immediately from the furnace and pour into ingots. Do not allow the hardener to reach a bright red heat before removing it from the furnace.

When cold, the hardener will be rather brittle and no difficulty will be experienced in breaking it into pieces suitable for making weights.

To make the 8 per cent aluminum-copper alloy, or regular No. 12 aluminum, melt together the following proportions of hardener and pure aluminum, in a crucible of suitable size:

	Pounds
Pure aluminum	84
Hardener	16

If a softer alloy is required, smaller percentages of hardener may be added.

Great care always must be exercised in making alloys of aluminum if good results are desired. This involves constant supervision throughout the melting process. A bright red heat is always dangerous to aluminum, because being so chemically active, it attacks the materials of which the crucible is made; merely rubbing the sides of the crucible with the stirring rod frequently will start a reaction, the result of which is always harmful to the alloy. The temperature of the metal, therefore, should be kept no higher than a dull red, approximately 800 degrees Cent.

While thin castings require pouring at a temperature of about 800 degrees Cent. in many cases to insure proper running, this is too high for castings of thick section. The latter should be poured no hotter than 700 degrees Cent., and below this temperature if possible. Hot-poured aluminum castings will be porous, as indicated by black spots. At a red heat aluminum greedily absorbs the steam generated by contact with the moist sand, at the same time decomposing it, and combines with the oxygen to form alumina which is a white solid. It retains the lively hydrogen in the form of minute bubbles which are disseminated throughout the mass of the casting.

ALUMINUM ALLOYS
(Concluded)

An alloy of aluminum, zinc and copper, employed extensively for automobile work, follows:

	Pounds
Pure aluminum	79
Aluminum hardener	6
Zinc	15

The specific gravity of this alloy is 3.10; the tensile strength is as high as 25,000 pounds per square inch and the casting qualities are good.

The following aluminum alloy also is frequently used:

	Pounds
Pure aluminum	65
Zinc	35

The specific gravity of this alloy is 3.30 and its tensile strength is in excess of 30,000 pounds per square inch.

The following alloy has good casting qualities and possesses about the same tensile strength as the alloy previously named:

	Pounds
Pure aluminum	70
Aluminum hardener	7
Zinc	23

A good, white alloy, suitable for pattern plates, follows:

	Pounds
Pure aluminum	79
Aluminum hardener	4
Tin	2
Zinc	15

Another alloy suitable for the same purpose as the foregoing, follows:

	Pounds
Pure aluminum	80
Aluminum hardener	10
Tin	10

When melting aluminum alloys the pasty dross that occasionally forms on the surface of the metal can be removed by the addition of a small piece of fused zinc chloride. The effect of this chemical is to cause a reaction which effects a separation of the dross and entangled metal, the former being liberated in the form of dust.

HARDENING EFFECT OF ADDITIONS OF COMMERCIAL METALS TO ALUMINUM

ZINC ALLOYS

The hardening effect of zinc on aluminum is illustrated by the following ests.

Alloy No. 1	Per cent	Alloy No. 2	Per cent	Alloy No. 3	Per cent
luminum	96.00	Aluminum	92.00	Aluminum	85.00
inc	4.00	Zinc	8.00	Zinc	15.00

The specimens were tested for hardness by the conical impression test. The test pieces were cast in chilled iron molds, but as this would give a false value or aluminum, the specimens were annealed before being tested. Two tests were aken of each specimen; one after it had been softened by ordinary annealing, nd the other after it had been annealed for a period of three hours at a temerature of 500 degrees Cent..

The hardness of No. 1, softened, was 41, and after long annealing 39.5. The hardness of No. 2, softened, was 48, and annealed, 54.5. The hardness of No. 3, softened, was 75, and annealed, 97.5. These figures are the average of wo hardness tests.

COPPER ALLOYS

The effect of copper in hardening aluminum is shown as follows:

Alloy No. 4	Per cent	Alloy No. 5	Per cent	Alloy No. 6	Per cent
luminum	98.00	Aluminum	96.00	Aluminum	92.00
opper	2.00	Copper	4.00	Copper	8.00

The hardness of No. 1, softened, was 50.5, and annealed, 57.5; of No. 2, ftened, 64.25, and annealed, 86.5, and of No. 3, softened, 75.5, and annealed, .5.

COPPER AND TIN ALLOYS

When copper and tin were used together the hardening effect was as llows:

Composition			Hardness	
Aluminum Per cent	Copper Per cent	Tin Per cent	Chilled casting Softened	Annealed 3 hours at 400 degrees Cent.
92.00	4.00	4.00	68.00	71.5
88.00	4.00	8.00	69.50	70.0
88.00	8.00	4.00	80.50	79.5
84.00	8.00	8.00	84.50	83.0

The addition of tin it will be noted does not exercise any appreciable hardning effect on aluminum, while zinc is not as satisfactory as copper.

HARDENING EFFECT OF ADDITION OF COMMERCIAL METALS TO ALUMINUM

(Concluded)

Magnesium Alloys of Aluminum

The effect of magnesium in hardening aluminum is illustrated by the following tests.

Magnalium

	Per cent
Aluminum	98.00
Magnesium	2.00

The hardness of the chill-cast alloy, softened, was 57.5. When annealed at a temperature of 430 degrees Cent. for three hours, the hardness was 50.5. Other aluminum-magnesium alloys follow:

Alloy No. 1	Per cent	Alloy No. 2	Per cent	Alloy No. 3	Per cent
Aluminum	96.00	Aluminum	92.00	Aluminum	85.00
Magnesium	4.00	Magnesium	8.00	Magnesium	15.00

Hardness

Alloy No. 1		Alloy No. 2		Alloy No. 3	
Annealed	80.00	Annealed	100.50	Annealed	Not tested
Softened	80.00	Softened	102.50	Softened	148.50

Aluminum, Magnesium and Copper Alloys

Composition			Comparative Hardness	
Aluminum Per cent	Magnesium Per cent	Copper Per cent	Chilled Castings Softened	Annealed 3 hours at 400 degrees Cent.
95.50	0.50	4.00	77.50	108.50
96.00	2.00	2.00	86.50	100.50
94.00	2.00	4.00	101.50	132.50
94.00	4.00	2.00	99.00	66.50
92.00	4.00	4.00	116.50	102.00

The hardening effect of magnesium on aluminum is greater than that of either copper or zinc. The effect of the three elements is approximately, as follows:

To produce an alloy twice as hard as pure aluminum there is required zinc, 15 per cent; copper, 8 per cent; magnesium, 4 per cent. The hardening effect of magnesium is therefore, twice that of copper, and nearly four times that of zinc.

DATA ON ALUMINUM BRONZE

Iron in Aluminum Bronze

of an alloy of aluminum, 10 per cent; iron, 1 per cent; r, 89 per cent, with cast-to-size test bars were made. inches diameter were placed on either end of the grips. were made with long grips. Four bars were cast and follows:

	Bar, 1.	Bar, 2.	Bar, 3.	Bar, 4.
stic limit	18,600	18,300	26,500	22,600
imate strength	76,600	77,100	74,200	75,600
ngation	26.0	27.5	23.0	27.0
luction of area.........	24.8	29.8	27.5	29.9

lastic limit and ultimate strength are given in pounds per h, the reduction of area in percentages, and the elonga- rcentage of stretch in 2 inches.

Phosphorus in Aluminum Bronze

used as control:

	Per cent
opper	89.00
luminum	10.00
ron	1.00

with phosphorus:

	Per cent
opper	88.90
luminum	10.00
on	1.00
hosphorus	0.10

ts of physical tests were as follows:

	Control bar	Treated bar
point, pounds per square inch	26,100	27,700
ate strength, pounds per square inch..	76,400	70,000
ation per cent in 2 inches	21.0	12.5
tion of area, per cent	17.6	17.5

Silicon Aluminum Bronze

ffect of silicon is illustrated by the following tests. The isted of the following proportions:

	Per cent
opper	89.50
luminum	10.00
licon	0.50

s of physical tests were as follows:

ield point, pounds per square inch..............	28,800
ltimate strength, pounds per square inch........	77,000
longation in 2 inches, per cent..................	1.5
eduction of area, per cent	1.4

DATA ON ALUMINUM BRONZE
(Concluded)

Adding Manganese to Aluminum Bronze

The effect of adding manganese to aluminum bronze is shown by test. The alloy tested had following composition:

	Per Cent
Copper	89.00
Aluminum	10.00
30 per cent manganese copper	1.00

The alloy was cast into sand molds containing imprints of the standard nonferrous test bars, which were cast to size having 2-inch risers on either end of the grips as is usual in the case of aluminum bronze. The physical properties, on an average of three test bars were as follows:

Tensile strength, pounds per square inch	63,800
Elastic limit, pounds per square inch	19,700
Elongation, per cent in 2 inches	49.3
Reduction of area, per cent	42.1

Calcium-Aluminum Bronze

The effect of calcium on aluminum bronze is illustrated by test. The alloy tested had the following composition:

Copper	89.00
Aluminum	10.00
10 per cent calcium-copper	1.00

The alloy was cast into sand molds and the bars were cast to size The average physical properties of three bars were as follows:

Tensile strength, pounds per square inch	54,000
Elastic limit, pounds per square inch	19,700
Elongation, per cent in 2 inches	22.5
Reduction of area, per cent	30.4

Iron in Aluminum Bronze

An alloy was cast into test bars attached to keel block in the manner usual with manganese bronze. The following alloy was tested:

	Per Cent
Copper	89.00
Aluminum	10.00
Iron	1.00

The bars were cut from the block and machined to standard size. The following results were obtained:

Tensile strength, pounds per square inch	69,600	73,100
Yield point, pounds per square inch	20,400	23,000
Elongation, per cent in 2 inches	19.5	22.5
Reduction of area, per cent	23.0	21.6

ALUMINUM ALLOYS USED IN AIRCRAFT

BRACES OF ZEPPELINS

	Per Cent
Aluminum	99.07
Zinc	0.13
Iron	0.38
Silicon	0.36
Copper	0.06

This metal was simply commercially pure aluminum, as the zinc, iron, silicon and copper are the usual impurities.

CHANNEL SECTIONS OF ZEPPELIN

	Per Cent.
Aluminum	88.68
Zinc	9.10
Iron	0.43
Silicon	0.49
Copper	0.70
Tin	0.15
Manganese	0.43
Nickel	Trace

This alloy consists essentially of commercial aluminum stiffened with zinc, copper and manganese. A somewhat softer alloy was used for the brackets connecting the angles of the various sections of the frame. This alloy follows:

	Per Cent
Aluminum	90.27
Zinc	7.80
Iron	0.45
Silicon	0.37
Copper	0.73
Tin	0.11
Manganese	0.27
Nickel	Trace

As in the other alloys the iron, silicon and the tin also trace of nickel are not added intentionally, but exist as a part of the pure aluminum. The alloy could be successfully imitated as follows:

	Per Cent
Aluminum (commercially pure)	91.25
30 per cent manganese copper	1.00
Zinc	7.75

All the above alloys are soft and ductile, too soft for most casting purposes, but suitable for fabricated shapes such as the channel sections and connecting parts.

PATENTED ALUMINUM ALLOYS

An alloy that is claimed to be particularly adapted to casting purposes is the subject of a patent by W. A. McAdams, United States patent No. 1146185. The following proportions are suggested:

	Per cent
Aluminum	82.00
Copper	12.00
Cadmium	5.00
Silver	1.00

In United States patent No. 1156093, Charles Pack protects alloys of aluminum adapted for die-casting purposes. Two alloys are suggested as follows:

For small, simple castings:

	Per cent
Aluminum	91.00
Copper	9.00

The inventor finds it desirable and necessary to increase the percentage of copper as the castings increase in size and become more complicated. The highest percentage of copper he has been able to use successfully, follows:

	Per cent
Aluminum	80.00
Copper	20.00

The addition of iron to aluminum alloys also is suggested by A. W. Morris in United States patent No. 1227174. The inventor claims the presence of iron operates to reduce the shrinkage of the castings or forgings, thus overcoming the danger of cracking. The iron, it is claimed, also increases the density of the castings and the tensile strength and elongation. The iron can be added to any alloy of aluminum, but its aluminum content should not be under 70 per cent.

The percentage of iron should not be less than 1 per cent, or more than 6 per cent, and the silicon content of alloy should be kept low.

A combination of aluminum and beryllium has also been patented by H. S. Cooper, United States patent No. 1254987. It is claimed the alloy produced by melting together the two metals is greatly superior to aluminum alone, and also of lower specific gravity.

PATENTED ALUMINUM ALLOYS

(Concluded)

The following alloy was patented by W. A. McAdams, United States patent No. 1095653:

	Per cent
Aluminum	70.00
Zinc	22.00
Antimony	5.00
Copper	3.00

The object in adding antimony was doubtless to control the shrinkage of the alloy.

The following alloy was patented by C. P. Van Gundy, United States patent No. 1098137:

	Per cent
Aluminum	86.50
Zinc	9.70
Lead	2.50
Copper	1.30

The object gained by addition of lead is a closer grained alloy that will resist pressures.

The following alloy, patented by W. A. McAdams, United States patent No. 1104369, is claimed to be suitable for "hammered silverware":

	Per cent
Aluminum	80.00
Silver	4.00
Tin	8.00
Cadmium	8.00

As manganese is frequently used in making alloys of aluminum it is interesting to note, this has been made the subject of a patent by Alfred Wilm, Berlin, Germany, United States patent No. 1130785, March 9, 1915.

The inventor states the addition of manganese is particularly advantageous when it also contains up to 2 per cent magnesium. As an example the following alloy is given:

	Per cent
Aluminum	93.10 to 96.50
Magnesium	0.5
Copper	5.6 to 3.00

This alloy has certain properties, but the addition of as little as 0.5 per cent manganese, increases the strength about 17 per cent, the hardness, by the ball test, about 10 per cent, and at the same time the alloy is better to file and work.

COMMON CASTING COPPER

A very useful alloy for soldering irons, copper hammers and all copper castings where high conductivity is not essential, follows:

	Pounds
Copper	96
Zinc	4

This formula will always be found satisfactory, as the zinc is sufficiently high to insure solidity, whether ingot or scrap copper is used. The color of the metal is sufficiently red to pass for copper, and the castings can be relied upon to show up clean, bright, sound and free from abnormal shrinkage.

The copper should be melted in a clean crucible, and, when first charged, two tablespoonfuls of salt are added. The chlorine gas from this protects the copper from excessive oxidation until it settles down in a liquid state, when it should be covered with charcoal, hard wood chips, tan bark, or any organic substance that forms charcoal. The zinc should be added after the copper is melted. The mixture is then thoroughly stirred and the metal is allowed to superheat a few minutes before being cast. If the color of the metal is not sufficiently red, the zinc, with careful melting, may be reduced to 2 per cent.

CHEAP RED METAL

This mixture has a wide range of usefulness for red brass castings when high tensile strength and elongation are not necessary. The metal is suitable for plumbers' goods, small bushings, valves and cocks, gas meter parts, or any red metal castings that are to be rapidly finished on turret lathes. The mixture is as follows:

	Per cent
Copper	83.84
Lead	8.33
Zinc	8.33

Or,	Pounds
Copper	20
Lead	2
Zinc	2

This mixture is easy to make. The copper is melted first, and, when charged, a small quantity of common salt is also placed in the crucible. When melting begins, charcoal is added to form a cover to protect the metal from oxidation. When the copper has melted, the zinc, which has been allowed to become hot by lying on top of the furnace, is dropped in with the tongs. The mixture is then stirred, the lead added, and the stirring vigorously repeated. When ready to pour, the surface of the metal should be clean and liquid under its cover of charcoal. The castings run smooth, with a nice bronze color, and the metal should be poured hot, although it is not necessary for it to boil.

DEOXIDIZERS FOR COPPER AND ITS ALLOYS

Aluminum

This metal can be used in the production of copper castings to prevent porosity, the amount to be added varying from one-half to one per cent. The castings are, however, liable to run drossy.

Aluminum in Yellow Brass

Yellow brass is greatly improved for many purposes by the addition of aluminum, the amount to be added varying from one to six ounces per 100 pounds of metal. The brass is deoxidized and strengthened, its fluidity is greatly increased, and the zinc oxide smoke is greatly reduced. Aluminum in this connection is most valuable in the case of light castings, as it adds to the certainty with which the metal can be poured, and owing to the increase in fluidity the loss from misrun castings is considerably reduced. The metal should be poured as cool as is consistent with running the castings, and it must enter the mold without agitation, to prevent the formation of dross.

Boron

The use of boron nitride, boron suboxide and boron carbide have been used as deoxidizers of copper and can now be obtained commercially. The nitride is used to make solid castings in the proportion of 2 per cent. As the nitride forms no alloy the copper is left in a state of purity, and the resulting castings possess high electric conductivity.

Calcium

Calcium is a powerful deoxidizer of copper and its alloys. It has been little used for this purpose in the past, as experience has shown this element to be a disappointment as a deoxidizing agent in nonferrous alloys.

COPPER CASTINGS FOR ELECTRICAL PURPOSES

It is important that copper castings used for switchboards, cable connectors, terminal lugs and other electrical work shall be as nearly pure copper as possible, in order that their electrical efficiency will be high. Absolutely pure copper cannot be cast, as it absorbs gases while being melted which cause the castings to be full of holes, or honeycombed. It is, therefore, necessary to add some element to the molten copper which will eliminate the gases and produce solid castings, and in ordinary casting copper, zinc produces the best results, but so much of it must be used that the metal is very little higher in conductivity than bronze. The copper must also cast well, and produce clean solid castings, and while magnesium gives the highest conductivity, silicon produces the cleanest and most reliable castings. The following mixture is therefore recommended:

Copper	100 pounds
Ten per cent silicon-copper	12 ounces

The tensile strength of this copper is 23,000 pounds per square inch, and the conductivity is high.

In order to obtain good results with such a small percentage of silicon, the copper must be very carefully melted. The ingots should be so placed in the crucible, that they do not extend over the top, and two tablespoonfuls of salt is added with the ingots, several pieces of charcoal being placed on top when the metal begins to sink down and before it melts. The other ingots to be melted should be placed on top of the pot until they become red hot, when they can be removed with the tongs and pushed into the molten metal, charcoal also being added from time to time, as required, to keep the metal covered. When all of the metal is melted in this manner its surface will be seen to be limpid beneath the charcoal. The silicon-copper, may now be added, having been previously warmed, and the contents of the crucible should be vigorously stirred with a plumbago stirrer. The metal should then be superheated ten minutes, and poured into the molds quite hot. Bottom-pour crucibles are best for this class of work, as they obviate the necessity of contaminating the metal with an iron skimmer.

COMPARATIVE HARDNESS OF COPPER ALLOYS

A careful investigation of the hardness of alloys of copper gives results as follows:

Alloys				Comparative Hardness		
Copper Per Cent	Tin Per Cent	Zinc Per Cent	Lead Per Cent	Chilled Castings	Annealed 3 Hours	Annealing Temperature Degrees Cent.
99.00	1.00	00	00	77.65	77.8	850
96.00	4.00	00	00	99.15	102.7	700
92.00	8.00	00	00	128.0	128.0	700
85.00	15.00	00	00	219.95	181.50	700
80.00	20.00	00	00	285.50	274.00	700
88.00	8.00	00	4.00	121.50	107.50	700
84.00	8.00	00	8.00	119.00	104.00	700
88.00	8.00	4.00	00	102.50	108.00	700
88.00	4.00	8.00	00	104.00	112.50	700
92.00	4.00	4.00	00	147.00	136.00	700
84.00	8.00	8.00	00	156.00	132.50	700
85.00	00	15.00	00	81.00	79.50	900
70.00	00	30.00	00	87.00	89.00	900
65.00	00	35.00	00	92.50	84.50	900
60.00	00	40.00	00	128.50	154.50	800
55.00	00	45.00	00	181.30	183.50	800
66.00	00	30.00	4.00	79.50	79.00	800
62.00	00	30.00	8.00	71.00	71.50	800
66.00	4.00	30.00	00	169.00	138.00	800
62.00	8.00	30.00	00	286.50	243.00	800
58.00	2.00	40.00	00	201.00	199.00	800

The hardness was determined by means of conical impression or *punch* tests of the kind which in contrast with impression tests usually employed with homogeneous substances give co-efficients of hardness that are independent of the magnitude of the load and of the depth of the impression.

COMPARATIVE HARDNESS OF COPPER ALLOYS
(Continued)

Alloys of Copper with Tin, Zinc and Aluminum

Copper Per Cent	Alloys: Tin Per Cent	Alloys: Zinc Per Cent	Alloys: Aluminum Per Cent	Comparative Hardness: Chilled Castings	Comparative Hardness: Annealed 3 Hours	Annealing Temperature Degrees Cent.
99.00	00	00	1.00	75.60	71.25	900
96.00	00	00	4.00	92.50	88.25	900
92.00	00	00	8.00	117.50	119.50	900
90.00	00	00	10.00	202.00	225.00	900
88.00	00	00	12.00	225.50	222.00	900
85.00	00	00	15.00	400.00	400.00	900
92.00	4.00	00	4.00	153.00	136.50	700
88.00	8.00	00	4.00	214.50	182.00	700
88.00	4.00	00	8.00	215.50	212.00	700
84.00	8.00	00	8.00	250.00	244.50	700
58.00	00	40.00	2.00	192.00	187.50	800

Copper-Nickel Alloys

Copper Per Cent	Alloys: Nickel Per Cent	Manganese Per Cent	Comparative Hardness: Chilled Castings	Comparative Hardness: Annealed 3 Hours	Annealing Temperature Degrees Cent.
92.00	8.00	00	67.50	70.00	900
85.00	15.00	00	79.50	85.50	900
70.00	30.00	00	103.00	119.50	900
70.00	15.00	15.00	92.50	96.00	900
55.00	15.00	30.00	93.00	93.50	900
55.00	30.00	15.00	104.00	121.50	900
40.00	30.00	30.00	118.50	119.50	900

Copper-Manganese-Nickel Alloys

Copper Per Cent	Alloys: Nickel Per Cent	Manganese Per Cent	Comparative Hardness: Chilled Castings	Comparative Hardness: Annealed 3 Hours	Annealing Temperature Degrees Cent.
92.00	4.00	4.00	85.35	91.50	900
88.00	8.00	4.00	95.50	98.00	900
88.00	4.00	8.00	105.50	105.50	900

COMPARATIVE HARDNESS OF COPPER ALLOYS

(Continued)

Copper, Nickel and Manganese Alloys

Alloy			Comparative Hardness Averaged		
Copper Per cent	Nickel Per cent	Manganese Per cent	Chilled Casting	Annealed 3 hours	Annealing Temp. Deg. Cent.
84.00	8.00	8.00	111.00	117.50	900
81.00	4.00	15.00	119.00	113.00	900
77.00	8.00	15.00	127.00	119.00	900

Composition of Alloy

	Per Cent
Copper	64.00
Tin	2.00
Aluminum	2.00
Iron	2.00
Zinc	30.00

This alloy is known as Durana metal. Its hardness in chilled castings averages 197.50; when annealed at 800 degrees Cent. for 3 hours its hardness is 241.50 as determined by the conical impression test.

Ferrobronze Alloy

Composition of Alloy

	Per Cent
Copper	58.00
Zinc	40.00
Iron	2.00

The hardness of ferrobronze in chilled castings is 137.50; when annealed at 800 degrees Cent. for 3 hours the hardness is 150.50.

Copper and Bismuth Alloys

Alloy No. 1

	Per Cent
Copper	96.00
Bismuth	4.00

Alloy No. 2

	Per Cent
Copper	92.00
Bismuth	8.00

The hardness of alloy No. 1 is 51.65 in chilled castings, and 49.75 when annealed. The hardness of No. 2 alloy is 55.80 when chilled, and 61.15 when annealed.

COMPARATIVE HARDNESS OF COPPER ALLOYS
(Concluded)

Copper and Silver Alloys

The comparative hardness of alloys of copper and silver as determined by the conical impression test is as follows:

Alloy No. 1	Per Cent	*Alloy No. 2*	Per Cent
Copper	96.00	Copper	92.00
Silver	4.00	Silver	8.00

The hardness of alloy No. 1 is 80.40 in chilled castings and 88.50 when annealed at a temperature of 700 degrees Cent. for a period of 3 hours.

Copper and Antimony Alloys

Alloy No. 1	Per Cent	*Alloy No. 2*	Per Cent
Copper	96.00	Copper	92.00
Antimony	4.00	Antimony	8.00

The hardness of alloy No. 1 is 102.00 in chilled castings, and 101.50 when annealed at a temperature of 590 degrees Cent. for a period of 3 hours.

Copper and Magnesium Alloys

Alloy No. 1	Per Cent	*Alloy No. 2*	Per Cent	*Alloy No. 3*	Per Cent
Copper	99.00	Copper	96.00	Copper	92.00
Magnesium	1.00	Magnesium	4.00	Magnesium	8.00

The hardness of alloy No. 1 is 95.05 in chilled castings, and 90.30 when annealed at 700 degrees Cent. for 3 hours. The hardness of No. 2 chilled is 183.00; and annealed, 183.50. The hardness of No. 3 alloy is 303 chilled, and 302 annealed. These values were obtained in the same manner as those of all the previously mentioned alloys, and illustrate the intense hardening effect of magnesium on copper which is almost double that of tin from 4 per cent magnesium up, and approximately 11 times that of zinc.

COMPARATIVE HARDNESS OF WHITE METALS

The tests which gave the following results were made by the conical impression method.

Alloys				Comparative Hardness		
Tin Per Cent	Lead Per Cent	Antimony Per Cent	Copper Per Cent	Chilled Castings	Annealed 3 Hours	Annealing Temperature Degrees Cent.
96.00	4.00	00	00	13.35	14.55	150
92.00	8.00	00	00	16.00	14.30	150
85.00	15.00	00	00	15.50	14.15	150
70.00	30.00	00	00	11.50	12.70	150
50.00	50.00	00	00	9.90	10.15	150
96.00	00	00	4.00	12.75	11.75	200
92.00	00	00	8.00	15.50	14.55	200
85.00	00	00	15.00	24.30	23.45	200
96.00	00	4.00	00	16.60	14.80	200
92.00	00	8.00	00	21.10	21.15	200
85.00	00	15.00	00	25.25	23.00	200
70.00	15.00	15.00	00	20.35	22.35	150
55.00	30.00	15.00	00	15.10	18.55	150
88.00	00	8.00	4.00	27.20	23.60	200
84.00	00	8.00	8.00	30.15	27.70	200
81.00	00	15.00	4.00	29.30	26.60	200
77.00	00	15.00	8.00	33.90	33.20	200

From the above it will be noted that lead has a softening effect on tin and that copper and antimony together have the greatest hardening effect.

Hardness of Alloys of Tin and Zinc

Alloy No. 1	Per Cent	Alloy No. 2	Per Cent	Alloy No. 3	Per Cent
Tin	99.50	Tin	99.00	Tin	96.00
Zinc	0.50	Zinc	1.00	Zinc	4.00

The hardness of No. 1, was 11.15, unannealed and 10.35 annealed. Of No. 2, unannealed and 14.15 annealed, of No. 3, 17.00 unannealed and 15.45 annealed.

COMPARATIVE HARDNESS OF WHITE METALS
(Concluded)

HARDENING EFFECT OF BISMUTH ON TIN

	Alloy No. 1 Per cent		*Alloy No. 2* Per cent
Tin	99.50	Tin	99.00
Bismuth	0.50	Bismuth	1.00

The hardness of No. 1 alloy unannealed was 11.90, and when annealed 11.75. The hardness of No. 2 alloy was 14.85 unannealed and 14.30 when annealed. With higher percentages of bismuth the hardening effect was more evident.

	Alloy No. 3 Per cent		*Alloy No. 4* Per cent
Tin	96.00	Tin	92.00
Bismuth	4.00	Bismuth	8.00

The hardness of No. 3 alloy was 26.65 unannealed, and 25.60 when annealed, that of No. 4 was 29.25 unannealed, and 28.90 when annealed.

HARDENING EFFECT OF ALUMINUM AND MAGNESIUM ON TIN

Alloys Tin Per Cent	Aluminum Per Cent	Magnesium Per Cent	Comparative Hardness Averaged Chilled Casting	Annealed 3 Hours	Annealing Temperature Degrees Cent.
99.75	0.25	00	14.25	12.75	210
99.50	0.50	00	16.50	13.50	210
99.00	1.00	00	17.35	14.35	210
98.00	2.00	00	20.15	14.25	210
99.50	00	0.50	20.05	15.80	180
99.00	00	1.00	25.50	15.65	180
98.00	00	2.00	31.85	18.50	180

In the above tests the great hardening effect of magnesium is illustrated and in this connection the great effect that annealing has in softening these alloys may be pointed out.

HARDNESS OF BEARING METALS

Hardness tests carried out by F. Giolitti and M. Marantonio, of Italy, gave the following results:

Copper, per cent	Tin, per cent	Lead, per cent	Hardness, Brinell
95.50	4.50	.....	49
91.20	8.80	.....	63
83.70	16.30	.....	77
74.10	25.90	.....	230
91.10	3.90	5.00	46
87.00	8.00	5.00	61
81.20	13.70	5.10	93
87.00	2.40	10.60	39
81.60	8.00	10.40	48
75.70	13.90	10.40	86
81.80	4.10	14.10	39
75.50	9.20	15.30	57
75.00	5.00	20.00	44
68.00	12.00	20.00	70
80.00	.....	20.00	23
60.00	.....	40.00	13

The foregoing results were obtained on cast alloys by the Brinell hardness testing method. A steel ball, 10 millimeters in diameter was used, and the pressure applied was 500 kilograms, or 1100 pounds. The results indicate how hardness is affected by the content of lead and hardness increases in proportion to the percentage of tin added.

PROPRIETARY BEARING ALLOYS

The following bronzes are used extensively as bearing alloys, and while the names by which they were known when first produced have generally been discontinued, occasionally one of these alloys is specified by its original name. The list of alloys presented herewith permits of the easy identification of any of these alloys:

"S" Bearing Metal

	Per Cent
Copper	79.70
Tin	10.00
Lead	9.5
Phosphorus	0.80

"S" bearing metal also is used as an acid-resisting alloy. The amount of phosphorus can be varied to best meet the requirements of individual cases. The difficulties of making castings are increased in proportion to the increase of phosphorus. When the phosphorus is eliminated, the alloy becomes a straight 80 copper, 10 tin and 10 lead mixture.

Ex. B. Metal, Pennsylvania Railroad

	Per Cent
Copper	76.80
Tin	8.00
Lead	15.00
Phosphorus	0.20

"Ex. B. Metal" is used for car journal bearings and also sometimes for anti-acid purposes.

Ajax Plastic Bronze

	Per Cent
Copper	65
Tin	5
Lead	30

Ajax plastic bronze also is used extensively for car journal bearings and occasionally is used as an acid-resisting alloy.

PROPRIETARY BEARING ALLOYS
(Concluded)

Ajax Metal

	Per Cent
Copper	77.00
Tin	11.50
Lead	11.50

A small amount of phosphorus may be added to Ajax metal to reduce oxides formed in melting. About 0.25 per cent of 15 per cent phosphor copper is sufficient for this purpose.

Carmelia Metal

	Per Cent
Copper	70.00
Tin	4.50
Lead	15.00
Zinc	10.00
Iron	0.50

Carmelia metal is a complex alloy. The advantages of the iron addition are rather doubtful.

Carbon Bronze

	Per Cent
Copper	75.00
Tin	10.00
Lead	14.50
Carbon	trace

Cornish Bronze

	Per Cent
Copper	77.80
Tin	9.50
Lead	12.50
Phosphorus	0.20

Damascus Bronze

	Per Cent
Copper	76.90
Tin	10.50
Lead	12.50
Phosphorus	0.10

BABBITT AND ANTIFRICTION METALS

Genuine Babbitt for Heavy Service

	Per Cent
Tin	89
Antimony	8
Copper	3

Standard Genuine Babbitt

	Per Cent
Tin	89.00
Antimony	7.50
Copper	3.50

No. 1 Calumet and Hecla (Hard Babbitt)

	Per Cent
Tin	83.50
Antimony	11.00
Copper	5.50

Armature Babbitt

	Per Cent
Tin	87.00
Antimony	8.00
Copper	5.00

This mixture is softer than No. 1 Calumet and Hecla.

Motor Metal (Very Hard)

	Pounds
Tin	100
Antimony	10
Copper	10

Although babbitts with a tin base are expensive mixtures, there are many conditions for which their use is justified and no substitution can be made.

BABBIT AND ANTIFRICTION METALS
(Concluded)

No. 2 Calumet and Hecla

	Pounds
Tin	60.75
Antimony	10.50
Lead	25.00
Copper	3.75

Calumet and Hecla No. 2 is eminently adapted as a lining metal for large crankshaft and other bearings for corliss engines.

Babbitt Cheaper than Calumet and Hecla No. 2

	Pounds
Lead	50
Tin	35
Antimony	15

Hard Lead

	Pounds
Lead	80
Antimony	20

Hard lead is improved considerably by the addition of a small percentage of tin and a reduction in the antimony, as follows:

	Pounds
Lead	80
Antimony	15
Tin	5

Babbitt Used on Marine Engines

	Pounds
Lead	72
Tin	21
Antimony	7

BABBITTS USED IN AUTOMOBILES

		Per Cent
No. 1		
	Tin	88.00
	Antimony	8.00
	Copper	4.00
No. 2.		
	Tin	61.50
	Antimony	10.50
	Copper	3.00
	Lead	25.00
No. 3 Special.		
	Tin	31.00
	Antimony	10.00
	Copper	1.00
	Lead	58.00
No. 4 Special.		
	Tin	5.00
	Antimony	15.00
	Lead	80.00
No. 5.		
	Tin	10.00
	Antimony	6.66
	Copper	3.33
	Lead	80.00
No. 6.		
	Tin	75.00
	Antimony	10.00
	Copper	3.00
	Lead	12.00

HEAT-RESISTING CASTINGS

ALUMINUM BRONZE

	Per Cent
Copper	90.00
Iron	0.50
Aluminum	9.00
30 per cent manganese copper	0.50

Melt the copper under charcoal, add the iron in the form of loosely coiled tin plate clippings, or thin, clean wire. Stir vigorously, add 2 per cent of the aluminum, again stir to incorporate all the iron, add the manganese copper and lastly the remainder of the aluminum. Gate the castings from the bottom. Use heavy risers to feed metal to supply the shrinkage, and pour the molds before the metal appears dull in color. The castings, if small in section will possess approximately the following physical properties:

Tensile strength, lbs. per sq. inch	80,000
Yield point, lbs. per sq. inch	26,000
Elongation, per cent in 2 inches	30.00
Reduction of area, per cent	28.00

Aluminum bronze is tough and ductile up to a red heat and can be forged.

HEAT RESISTING BRONZE

	Per Cent
Copper	91.00
Tin	4.50
5 per cent phosphor-tin	4.00
Lead	0.50

Melt the copper under charcoal, add 1 per cent of the phosphor-tin, then the ordinary tin, next the balance of the phosphor-tin, and lastly the lead. Stir thoroughly. Use large risers to feed the castings solid all through, and pour the metal at a temperature at which it appears bright. This alloy is phosphor-bronze.

Brass containing more than 10 per cent of zinc is not suitable for heat-resisting castings.

ODD AND UNUSUAL ALLOYS

Helmet Metal

This is a somewhat meaningless name for an alloy, but the mixture has been on the market several years and is used as a spring metal. Its composition follows:

	Per Cent
Copper	72
Zinc	28

This alloy is simply a yellow brass minus the tin, and resilience is imparted to it by cold-rolling or drawing. The greatest resilience is imparted by working it near to the fatigue point. Helmet metal is too soft a mixture for sand castings and is not used for this purpose.

Montana Gold

This alloy formerly was used extensively for table flat ware. It resembles 18-carat gold when polished, and with the exception of the aluminum content, is practically the brass known as *Gilding*. The composition of Montana gold is approximately as follows:

	Per Cent
Copper	89.00
Zinc	10.50
Aluminum	0.50

Platinoid

This alloy is in widespread use as an electrical resistance metal. It is practically a 25 per cent nickel silver. Its composition follows:

	Per Cent
Copper	53.50
Manganese Copper (30 Per Cent)	0.50
Nickel	24.50
Zinc	21.00
Iron	0.50

Noheet Metal

This alloy is used as an antifriction metal and at one time was widely exploited. The fact that it contains no copper and tin and antimony only in small amounts was emphasized, although these metals have never been considered detrimental to such alloys, but the reverse. The composition of *Noheet* metal follows:

	Per Cent
Lead	98.41
Sodium	1.40
Tin	0.08
Antimony	0.11

An easy way of making this alloy is to melt the lead until it is just liquid, when 2 per cent of sodium is added.

Nonpareil Antifriction Metal

This alloy has been on the market for an extended period and by analysis has the following constitutents:

	Per Cent
Lead	78.35
Antimony	16.70
Tin	4.95
Copper	Trace

ODD AND UNUSUAL ALLOYS
(Concluded)

Ounce Metal

Ounce metal derives its name from the fact that one ounce each of the white metals is added to one pound of copper. It is an excellent formula for steam goods that are not subjected to high pressures, and is extensively used for general castings. The formula follows:

	Pounds
Copper	80
Tin	5
Zinc	5
Lead	5

First melt the copper, using charcoal and salt, and, when liquid and clear, add the zinc which should have been previously warmed. Push it under the charcoal and stir vigorously. Add the tin next, and lastly the lead, again stirring.

No specific directions can be given regarding the proper pouring temperature, as that will vary greatly with the character of the work, some castings requiring hot metal, and others comparatively cool.

Key Metal

When ounce metal is made harder by doubling the quantity of tin, it is largely known by the trade name of Key metal. The formula then becomes:

	Pounds
Copper	80
Tin	10
Zinc	5
Lead	5

Key metal is used whenever a hard metal is desired, and it derives its name from being used in making the old-fashioned heavy door keys, because it is sufficiently stiff not to bend, runs fluid and files well.

It will be found useful for machinery castings when a stiff, hard metal is desirable.

NICKEL ALLOYS

Stiff, White Nickel Alloy

For all work requiring a stiff, white alloy that will cast fairly well and buff to a finish resembling nickel-plate, the following alloy will be suitable:

	Per Cent
Copper	65.00
Nickel	32.25
Aluminum	2.75

Melt the copper and the nickel together under charcoal, or use a flux consisting of fluorspar and lime, in a furnace capable of attaining a very high temperature. An oil or gas-fired furnace is preferable to one fired by coke or coal. When the alloy has reached a dazzling, white temperature, add the aluminum carefully and stir with an iron bar coated with alundum cement, thoroughly dried, and cast in dry sand or skin-dried molds faced with fine silica sand bonded with fine fireclay and molasses water. Pour the metal strongly and provide the castings with generous gating facilities.

Nickel Bronze

Nickel bronze is the name generally applied to any alloy of copper and tin containing nickel. The following alloy is a good example of this class of alloys and finds application as a material for making high-grade gears. The alloy follows:

Copper	85 pounds	11 ounces
15 per cent Phosphor-copper		5 ounces
Nickel	3 pounds	
Tin	11 pounds	

First melt the copper and the nickel together under a cover of charcoal, with a little borax; and when the copper is thoroughly melted and hot, add the phosphor-copper and stir; follow with the tin, stir once more and pour on the warm side.

BRAZING METAL

Brazing metal is an alloy of copper and zinc, with sometimes small percentages of lead, added for the purpose of improving its machining qualities. The content of zinc varies according to the amount of heat the castings will be subjected to, while being brazed. The greater the quantity of zinc it contains, the more fusible the alloy becomes, therefore, when the more refractory solders are to be used, or when the castings are so thin that there is danger of crumbling, the more nearly the brazing metal approaches casting copper in appearance and qualities.

Zinc is used in preference to tin in making brazing metal, because the copper-zinc alloys possess a certain amount of ductility at a red heat, and do not crumble with the same facility as the copper and tin metals. The color of the metal varies from a coppery hue, with the smaller percentages of zinc, to a reddish yellow, with the higher percentages, the structure of the metal being fibrous. The formula that is extensively used for flanges to be brazed onto copper pipe is as follows:

	Per cent
Copper	87
Zinc	12
Lead	1

The copper must be melted under a cover of charcoal, a little salt being added when the ingots become red. After the copper is melted and appears limpid beneath the charcoal cover, the zinc, having been previously warmed, is added in small pieces, the lead is then put in, and the mixture thoroughly stirred, when it is ready for casting.

EFFFCT OF MANGANESE-COPPER ADDITIONS

The addition of a small amount of manganese-copper is frequently advantageous in yellow alloys, as it eliminates surface pin holes in yellow brass castings, closes the grain and imparts a pleasing brown color to the casting. The following alloys are recommended:

No. 1—Yellow Brass

	Pounds	Ounces
Copper	66	12
Manganese-copper	0	4
Zinc	30	0
Lead	3	0

No. 2—Yellow Brass

	Pounds	Ounces
Copper	70	0
Manganese-copper	0	8
Zinc	25	0
Tin	1	8
Lead	3	0

Lamp Bronze

	Pounds	Ounces
Copper	76	0
Zinc	18	0
Tin	3	0
Lead	3	0
Manganese-Copper	0	2

Manganese-copper should be added to the metal after the copper is melted, and should be stirred in well, the surface of the copper being covered with a layer of charcoal. The zinc is next added, followed by the tin and lead. Manganese-copper should contain no iron, and as the content of manganese in the copper may vary, the quantity used in the alloys may be increased or decreased, if the amount given in the formulas does not give the required results. The best results from the use of manganese are obtained when the castings possess a light brown skin. If the color is sufficiently deep to injure the appearance of the castings, it will in all probability cause cold shuts; in this case the quantity should be reduced. If no external indication of the presence of manganese is visible, it may be advisable to increase the amount added to derive the full benefits of its use.

Ductile Yellow Brass

A mixture for a soft, ductile, yellow brass that can be riveted, follows:

	Pounds
Copper	68
Zinc	30
Lead	2

MISCELLANEOUS FORMULAS

Acid Resisting Alloys

While no copper alloy can be said to be acid-proof, there are some alloys that will resist acids much better than others, and because lead is more resistant to acids than most metals, the so-called acid-proof metals are generally highly leaded. An alloy of this type is as follows:

	POUNDS
Copper	72
Phosphor-copper (15 per cent)	3
Tin	1¼
Antimony	3¾
Lead	20

Melt the copper under charcoal, using a flux composed of four ounces of borax, two ounces of soda ash, and eight ounces of sharp sand. When melted, add the phosphor-copper, then the tin and antimony. Stir the metal thoroughly and add the lead. This alloy can be used for all castings that come into contact with acid fluids, but should not be used when great strength is also desirable. Should the castings bleed lead when taken hot from the molds, add two ounces of roll sulphur to the flux.

Strong Alloy

A stronger alloy for the same purpose, that will also prove satisfactory for bearings, follows:

	POUNDS
Copper	74
Manganese-copper (30 per cent)	1
Tin	5
Lead	20

Melt the copper and afterwards add the other component parts of the alloy in the order given.

Bearing Metal

Another mixture on the same order, possessing excellent antifriction qualities combined with low cost, follows:

	POUNDS
Copper	63
Manganese-copper (30 per cent)	5
Antimony	2
Lead	30

Melt the copper, add the manganese-copper, next the antimony and lastly the lead. Stir well, thickly cover with charcoal, drop two pounds of borax onto the charcoal, allow the water to boil out, then stir the contents of the crucible thoroughly.

BENEDICT NICKEL

Benedict nickel is most generally used in the form of sheet and tubing by the plumbing trade for lavatory fittings, but at the present there is a considerable demand for this alloy for bullet jackets and many foundrymen are considering the advisability of engaging in its manufacture in the form of bars for rolling. The formula follows:

	Per cent
Copper	80.00
Nickel	20.00

In making this alloy, it is advisable to place the nickel in the bottom of the crucible, with the copper on top. About 25 per cent of scrap of the same composition can be used with each charge and may be added with the copper and the nickel. It is good practice to use a deepener on top of the crucible to enable all the cold metals comprising the charge to be placed in the furnace at once. This deepener is the upper portion of a worn-out crucible and is placed loosely on top of the melting crucible in the capacity of a hopper. In case all the charge cannot be placed in the crucible and deepener, and scrap is used, it is better to reserve some of the copper than the scrap for future addition, as the latter has a higher melting point than the copper.

To protect the metals from oxidation, charcoal is frequently used as a cover, some of which should be added with the cold metals. It is a question, however, whether it is not better to avoid charcoal in connection with copper-nickel alloys, because if carbon is absorbed these alloys do not roll successfully; therefore, some contend that the following flux is more suitable:

	Per cent
Unslacked lime	67
Powdered fluorspar	33

Slack the lime to a cream, add the fluorspar, mix thoroughly and dry; use a minimum of one per cent.

Bring the metal to a white heat before removal from the furnace, stir well, and just before pouring, add 0.25 per cent of 30 per cent manganese-copper.

FUSIBLE ALLOYS

Alloys having low melting points find many industrial applications, being used as solders, for making fuse wire, fusible safety boiler plugs, for the measurement of temperatures, as hardening baths for steel and for the reproduction of medals. This class of alloys is composed of lead and tin in varying proportions, with the addition of small percentages of bismuth or cadmium to increase the fusibility of the metal. The composition and melting points of a number of fusible alloys are given in the following table.

Tin, per cent	Lead, per cent	Cadmium, per cent	Bismuth, per cent	Melting point, degrees Fahr.
25.00	75.00	0	0	482
34.00	66.00	0	0	441
40.00	60.00	0	0	412
50.00	50.00	0	0	370
60.00	40.00	0	0	334
66.00	34.00	0	0	340
43.50	43.50	0	13.00	311
40.00	40.00	0	20.00	283
34.00	33.00	0	33.00	258
20.00	30.00	0	50.00	212
18.75	31.25	0	50.00	208
25.00	25.00	0	50.00	200
12.50	25.00	12.50	50.00	140
26.60	13.40	10.00	50.00	100

Pure Banca tin is used by the United States government for making fusible safety plugs for boilers. The melting point of these alloys can be ascertained by suspending a sample of the metal on a wire in a bath of water or melted wax, in which a thermometer is immersed. The heat of the bath is increased gradually until the alloy melts, the temperature being indicated by the thermometer. Water can be used only for alloys melting below 212 degrees Fahr. Beyond this point the use of wax is necessary.

BABBITT METAL

There are several different methods of making babbitt metals. One is to first make an alloy of the most infusible metals and a sufficient amount of tin to bring the melting point within the range of the babbitt kettle. This is termed "hardening" and is added in the required proportions to the bath of melted tin in the kettle. By another method the more infusible metals are added to the bath of tin in the kettle, directly from the crucible in which they are melted. Still another method is pursued when the alloy is made entirely in the crucible in the absence of a babbitt kettle. In this case the copper is first melted and the antimony is added and is allowed to become thoroughly heated. The crucible is then removed from the furnace and the tin is added, the heat of the hardening metal and what is absorbed by the crucible being sufficient to liquefy the tin. The babbitt is then at a suitable heat for pouring, while if the tin were added to the other metals while in the furnace it might become overheated. Of these different methods, that by which the hardening metals are added in the liquid state is recommended.

A high-grade tin babbitt that will carry heavy loads and will withstand rough usage, being especially suitable for street railway service, is as follows:

	Pounds
Tin	85
Antimony	10
Copper	5

A small amount, as given above, can probably be more easily made in the crucible in which the copper and antimony are melted in the manner just stated. However, when several hundred pounds are made at a time, it is better to first melt the required amount of tin in the kettle and to obtain the correct weight it will probably be found necessary to ingot some of the tin when melted, as the original ingots of tin do not weigh exactly 100 pounds, but vary from 105 to 112 pounds. While the tin is being melted, the copper and antimony are also being melted in the crucible furnace. The copper is charged first and is melted under charcoal. Then the antimony is added in small pieces to avoid chilling the copper, each piece being allowed to melt before another is added. When each addition is melted the alloy is stirred, care being taken to feel to the bottom of the crucible to detect whether the copper has chilled and solidified. If the copper has chilled it will be necessary to superheat the metal until the entire bath is liquid, when the balance of the antimony can be added. When the copper and antimony are melted they can be poured into the bath of tin, which is stirred in the meantime. The liquid babbitt is then covered with a thin layer of powdered soft coal, stirred and cast.

SOLDERING ALLOYS

Silver Solder

It is well known that for the purpose of brazing there is no alloy that can compete with silver solder for making a satisfactory joint. Therefore, in spite of its high cost, it is used extensively for brazing band saws and other metal articles requiring a strong joint. What is known as a *Common Silver Solder* is made of the following mixture:

	Per Cent
Fine silver	66.50
Copper	22.25
Zinc	11.25

Although the foregoing alloy is expensive to produce, though almost indispensable, efforts have been made to cheapen it and still retain the good flowing qualities of this solder. The following alloys are examples of cheaper mixtures:

	Per Cent
Fine silver	50
Copper	33
Zinc	17

The above alloy has a deeper yellow color than the first one given. A cheaper mixture follows:

	Per Cent
Fine silver	37
Copper	50
Zinc	13

The color of the foregoing mixture more nearly approaches that of ordinary spelter solder than that of the other two alloys and it flows better than spelter solder.

For a solder that will melt at a low temperature and will flow easily, the following mixture is recommended:

	Per Cent
Silver	61
Copper	20
Zinc	14
Tin	5

The addition tin lowers the melting point and hardens the solder.

SOLDERING ALLOYS
(Concluded)

Brazing Solders

Ordinary brazing or hard solder is an alloy consisting of equal parts of copper and zinc. For special purposes the proportions of the two metals may vary within wide limits, according to the purpose for which they are intended. The fusing point of the solder must be below that of the article soldered. The higher the percentage of copper, the stronger and the more refractory the solder will be. To lower the fusing point, tin and lead are frequently added to the alloy. A number of typical formulas are given in the following table:

COPPER, POUNDS	ZINC, POUNDS	TIN, POUNDS	LEAD, POUNDS
58	42	..	..
54	45	1	..
53	47	..	..
50	50	..	..
45	50	3½	1½
34	66	..	..
44	50	4	2
57	28	15	..
48	48	4	..

Spelter Solder

Spelter solder also is, frequently, made by the addition of zinc to sheet brass. A number of these solder mixtures follow:

SHEET BRASS CLIPPINGS, POUNDS	ZINC, POUNDS	TIN, POUNDS
75	25	..
64	36	..
70	24	6
67	30	3

Borax is generally used as a flux with spelter solder, being reduced to a paste with water. Boric acid mixed with carbonate of soda also is used.

MELTING POINTS OF SOLDERS

Lead and Tin Alloys

The melting point of lead and tin alloys and the hardness by the Brinell method are as follows:

Tin per cent	Lead per cent	Melting Point, degrees Fahr.	Hardness Brinell method
0	100	618.8	3.90
10	90	577.4	10.40
20	80	532.4	12.16
30	70	491.0	14.50
40	60	446.0	15.80
50	50	401.0	15.00
60	40	368.6	14.60
66	34	356.0	16.70
70	30	365.0	15.80
80	20	388.4	15.20
90	10	419.0	13.30
100	0	466.0	4.10

The hardest alloy it will be noted contains 66 per cent tin and 34 per cent lead, which is practically the eutectic alloy and has the lowest melting point.

Hard Solders

The melting points of the copper and zinc alloys follow:

Copper per cent	Zinc per cent	Melting point degrees Fahr.
100	0	1980
96	4	1967
86	14	1890
80	20	1846
76	24	1796
72	28	1756
71	29	1746
66.4	33.6	1684
63	37	1666
60	40	1634
50	50	1616
48	52	1598
41	59	1544
35	65	1501
33	67	1477
29	71	1467
24	76	1364
20	80	1301

TESTS OF LEAD-TIN-ANTIMONY ALLOYS

Interesting results in the conservation of tin have been obtained from a number of tests of lead-tin-antimony alloys made in England, by O. W. Ellis. A total of 21 alloys were tested for yield point, tenacity, elongation, compressive strength and Brinell hardness. The greatest yield point and the greatest hardness were obtained with the following alloy:

	Per cent
Lead	68.80
Tin	9.10
Antimony	22.10

This is practically lead, 69 per cent; tin, 9 per cent and antimony, 22 per cent. All the alloys with more than 20 per cent of antimony either cracked or failed entirely during the compression test.

The greatest tensile strength and elongation was possessed by the following alloy:

	Per cent
Lead	82.00
Tin	8.90
Antimony	9.10

The greatest compressive strength was shown by the following alloy:

	Per cent
Lead	88.00
Tin	4.10
Antimony	7.90

The yield point, tenacity and elongation of the foregoing alloy were very low.

The following alloy is interesting because it approaches the composition of some commercial alloys:

	Per cent
Lead	71.00
Tin	18.60
Antimony	10.40

It developed a good yield point and tenacity, poor elongation, had medium compressive strength and fair hardness.

TESTS OF LEAD-TIN-ANTIMONY ALLOYS
(*Concluded*)

The following alloy is interesting because it approaches in composition a well-known anti-friction metal:

	Per cent
Lead	79.60
Tin	4.50
Antimony	15.90

In none of its properties was this alloy unusual. Its yield point was fair; tenacity, good; elongation, poor; compression and hardness medium as compared with the other alloys tested.

The most uniform alloy of the series was the following:

	Per cent
Lead	85.20
Tin	4.60
Antimony	10.20

This alloy could be closely approximated by weighing the proportions of the three metals as follows:

	Pounds
Lead	85.00
Tin	4.75
Antimony	10.25

This alloy possesses a fair yield point; excellent tenacity and elongation; high compressive strength and medium hardness. It appears to be the most serviceable of the 21 alloys tested.

As a result of the tests, the following conclusions were reached: The effect of the presence of the tin-antimony compound in such alloys is to render them weak and brittle. The general mechanical properties of the lead-tin-antimony alloys containing less than 15 per cent tin are improved by the addition of antimony in quantities not exceeding 10 per cent. The effect of increasing the antimony content of an alloy is to increase its hardness. There appears to be a region of maximum hardness in the vicinity of a composition containing lead, 70 per cent; tin, 10 per cent and antimony, 20 per cent.

SOLDERING ALUMINUM BRONZE

One great drawback to the extended use of aluminum bronze is the difficulty experienced in soldering the metal. This also applies to the tinning of the surface, so that this alloy cannot be used for articles that require the protection of a tin coating.

Copper Sulphate Flux

One method of soldering aluminum bronze employs a strong solution of copper sulphate as a flux. The parts to be soldered are immersed in the solution and are touched with an iron rod which produces a deposit of copper on the bronze. The parts are rinsed clean, when the coppered surfaces can be tinned and soldered. Instead of being coppered the surfaces can be nickeled, in which case it will appear that the bronze is really soldered.

The following flux, however, is more convenient as it permits the bronze to be coppered and soldered at one operation. Make the following solutions:

(1)	Dissolve dry copper carbonate	2 ounces
	Water	4 ounces
(2)	Hydrochloric acid	6 ounces
	Thin sheet iron	½ ounce

Let the iron stand in the acid over night, then gradually add solution No. 2 to solution No. 1. Add the acid slowly until effervescense ceases, and then add the rest rapidly. A clear green solution will result, to which is added 4 ounces of zinc chloride solution made as outlined on page 236. This flux will deposit copper under the heat of the soldering iron to which the solder will adhere. The following solder should be used in connection with the flux:

	Per cent
Tin	75
Lead	25

Melt together and run into convenient sticks.

FLUX FOR SOLDERING

When gated patterns become detached they may be replaced easily provided a good soldering fluid is employed. In making zinc chloride flux, the following precautions should be observed to obtain the best results:

Cleanliness is an important essential in making a good soldering fluid. The acid should be placed in a clean vessel, either glass or pottery. Metal containers should not be used as they are corroded by the acid, which contaminates the flux.

To make one gallon of soldering fluid use three quarts of commercial hydrochloric acid and place it in a suitable vessel; add zinc until the acid is *cut.* If the zinc is dirty it should be cleaned by dipping in acid and washing. Add the zinc to the solution, piece by piece, to prevent boiling over or the generation of sufficient heat to break the vessel if the latter is glass; stir the solution occasionally.

When the action between the zinc and acid has ceased, and no further bubbles appear when it is stirred, the solution should be filtered through several thicknesses of cloth tied over the mouth of a second jar to which the solution is transferred; this should have a capacity of at least one gallon. Add the following to the filtered solution:

(1)	Warm soft water	1 pint
	Sal-ammoniac	6 ounces

Add the sal-ammoniac to the water and stir until dissolved.

(2)	Warm soft water	1 pint
	Chloride of tin	4 ounces

Add the chloride of tin to the water and stir until dissolved, and mix the three solutions. The mixture will be slightly cloudy, and can be clarified by the addition of a small amount of hydrochloric acid, which should be added one drop at a time until the solution clears. This soldering flux will not spatter under the hot iron.

FLUXES FOR NONFERROUS METALS

Fluxes for Lead

The following flux is used in lead refining:

	Parts
Caustic soda	3
Roll sulphur	1

Mix together and add to the molten lead heated to 400 or 500 degrees Cent. allow the flux to act for a short time, then skim off. Another way of preparing the same flux is as follows:

	Parts
Caustic Soda	50
Sodium hyposulphite	50

Mix and use in the same manner as the former flux.

Flux For Grinding

	Pounds
Soda ash	25
Salt	25
Plaster of Paris	25
Fine charcoal	25

Mix 10 per cent of the flux with the grindings, and melt together in a hot furnace. Ingot both the metal and the liquid flux, and when the melt has cooled break away the slag with a hammer.

Ordinary Flux for all Kinds of Brass

	Pounds
Powdered glass	80
Calcined borax	10
Fine charcoal	10

Add sufficient to form a liquid film of slag over the molten metal and thus protect it from the oxidizing effects of the furnace gases.

FLUXES FOR NONFERROUS METALS
(Concluded)

Flux for Yellow Brass

	Parts
Salt cake	5
Silica	15
Coal dust	5
Bone ash	20

Salt cake is sodium sulphate and either the acid sodium sulphate or normal sodium sulphate may be used. Silica, of course, is sand and bone ash, calcium phosphate. This flux is used in the proportion of 1 or 2 per cent on the melted metal.

Flux for Grindings

	Parts
Plaster of paris	1
Soda ash	1
Salt	1
Fine charcoal	1

Mix the various ingredients thoroughly, and use from two to 10 pounds to 100 pounds of metal. Mix the flux thoroughly with the grindings, and melt at a high temperature.

Flux for Red Brass

	Parts
Powdered glass	8
Calcined borax	1
Fine charcoal	2

Mix the ingredients thoroughly, and use on red brass in the proportion of approximately 2 per cent.

Bell Metal Flux

	Parts
Soda ash	1
White sand	1
Borax	0.25
Yellow prussiate of soda	1

Mix thoroughly and use 1 per cent on bell metals after they are fluid. Add the flux, let it heat for a few minutes, then stir into the metal. This flux improves the tone of bell metals.

PATENTED NONFERROUS ALLOYS

Alloys for Lead-Coating Iron and Steel

The object of these alloys is to form a protective coating for iron and steel. The alloys are claimed to protect the iron as they are designed so they are not electropositive to the same. Three alloys are given under patent No. 1168663. The patentees are Clayton Mark Jr., and Clarence Mark. The alloys follow:

1	Per Cent	2	Per Cent	3	Per Cent
Lead	98.00	Lead	92.00	Lead	86.00
Zinc	1.00	Zinc	3.50	Zinc	6.00
Antimony	1.00	Antimony	4.50	Antimony	8.00

Sheathing Metal

A metal for sheathing hulls of vessels, and which it is claimed is also suitable for making piston rods, valve stems, shell bands and bearings has been patented by J. Monville, Patent No. 1199200. The alloy follows:

	Per Cent
Copper	95.500
Iron	3.000
Tin	0.625
Zinc	0.625
Nickel	0.625

Alloy for Springs

An alloy suitable for the springs of watches has been patented by G. E. Guillaume, Patent No. 1106206. The alloy follows:

	Per Cent
Iron	66.20
Nickel	28.50
Silicon	0.30
Chromium	1.50
Tungsten	1.00
Manganese	2.00
Carbon	0.50-1.00%

PATENTED NONFERROUS ALLOYS
(Concluded)

Nonmagnetic Alloy

An alloy that is claimed to be nonmagnetic, and is suitable for cutting tools, as it can be tempered, is the subject of a patent by J. A. Douglas. The patent was taken out in Great Britain. No. 8331. The alloy follows:

	Per Cent
Nickel	60.00
Copper	28.00
Ferromanganese	3.00
Aluminum	4.00
Tin	5.00

Also ferrosilicon, chromium and tungsten may be added as convenient.

Babbitts

Two alloys for babbitting have been patented in Great Britain by C. Billington, No. 11138. The alloys follow:

1	Per Cent	2	Per Cent
Tin	84.00	Tin	74.00
Antimony	9.00	Antimony	9.75
Copper	6.00	Copper	5.00
Nickel	1.00	Nickel	1.25
Lead	none	Lead	10.00

Packing Rings

An alloy for packing rings that will withstand superheated steam has been patented by G. E. Holder; U. S. Patent, No. 1127624. The proportions are approximate.

	Per Cent
Copper	20.00
Nickel	15.00
Lead	65.00

Brake Band Linings

An alloy for brake band linings, has been patented by Mary Holden, U. S. Patent, No. 1203338. The proportions are approximate.

	Per Cent
Lead	63.50
Copper	36.00
Phosphor Copper	0.50

MISCELLANEOUS DIPS

Dip for Copper Castings

It is frequently desirable to brighten small copper castings, such as rail bond lugs, commutator bars and similar parts. This may be accomplished by immersing them for several minutes in a solution composed of one quart of sulphuric acid to 10 quarts of water. This solution should be made in a wooden tank lined with asphalt. In the bottom of this tank a steam coil is placed for the purpose of keeping the fluid hot.

After the castings are removed from the acid they should be rinsed in hot lime water to prevent discoloration. The lime water contains five pounds of lime to the barrel of water, and the solution may be heated by a steam coil. A final rinsing in hot water completes the process of cleaning the castings.

To Prevent the Tarnishing of Brass When Dipped

To prevent the tarnishing of brass articles after passing through the acid dip, rinse in the following solution: Cream of tartar, five ounces, and clean, hot water, one gallon.

A Bright Dip for Brass, Bronze, Copper and German Silver

Sulphuric acid	2 gallons.
Nitric acid	1½ gallons.
Salt	2 ounces.

A momentary immersion is all that is usually required. The castings are rinsed in cold water, which is followed by cleaning in hot water. Hardwood sawdust is used for drying.

Pickle for Cleaning Brass Castings

Sulphuric acid	5 quarts.
Water	5 quarts.
Nitric acid	4 quarts.
Muriatic acid	1 pint

Add the sulphuric acid to the water gradually. After the solution has cooled, add the nitric and muriatic acids.

Dip for Removing Sand From Brass Castings

Muriatic acid	1½ gallons.
Nitric acid	1 quart.
Water	2 quarts.

Add the acids to the water, immerse the castings in the solution until clean, then rinse thoroughly in cold water.

PHYSICAL REQUIREMENTS OF NONFERROUS ALLOYS

The following specifications for the physical requirements of nonferrous alloys were issued by the United States bureau of steam engineering:

Alloy	Minimum tensile strength, lbs. per sq. in.	Yield point, pounds per sq. in.	Elongation in 2 ins., per cent
Gun bronze	30,000	15,000	15
Manganese bronze	60,000	30,000	20
Monel metal	65,000	32,500	25
Phosphor bronze	40,000	20,000	20

Method of Casting Test Pieces

On manganese bronze screw propellers, test coupons should be cast attached to the hub and to each blade, being cast flat on the blade or hub. Those on the blades will be attached at half the distance from the root of the periphery, and may be of any size found necessary to give a sound test specimen. The coupons are to be given no treatment other than machining to reduce them to the proper diameter. For castings weighing over 200 pounds, test pieces or coupons shall be taken in such a manner and from such parts of the casting as will thoroughly exhibit the quality of the metal, not less than three being taken for large propellers.

Monel Metal Test Coupons

For Monel metal propellers, three test coupons must be attached to the hub. Two will be tested and one retained in case of defect in either of the others. Castings of gun metal, manganese bronze, Monel metal, or phosphor bronze weighing less than 200 pounds finished, may be tested by lots or heat, a lot not to exceed 200 pounds, and a heat 500 pounds of finished castings. Each lot or heat will be represented by one test specimen when attached to a casting or when a casting is sacrificed to obtain a test specimen. If the castings are too small for the attachment of coupons, the test pieces may be cast separately from the same metal. Where test pieces are cast separately from the castings, two test pieces will be required, one to be poured before and one after the castings. Coupons shall be detached from the castings until they are stamped by the inspector. The color of the fracture of the test pieces and the grain of the metal must be uniform throughout.

COMPOSITIONS OF NONFERROUS ALLOYS

The following specifications for the composition of nonferrous alloys were issued by the United States bureau of steam engineering.

Specifications for Casting Materials

The composition must be made of such materials as will give the required chemical analysis. Scrap will not be used except such as may result from the process of manufacture of articles of similar composition.

Valve Bronze

	Per cent
Copper	87
Tin	7
Zinc	6
Iron	0.06*
Lead	1.00*

Manganese Bronze

	Per cent
Copper	57 to 60
Zinc	37 to 40
Tin	0.75
Iron	1.00*
Aluminum	0.50*
Manganese	0.30*

Monel Metal Castings

	Per cent
Copper	33
Nickel	60 minimum
Iron	6.5
Aluminum	0.5
Lead	None

Cast Naval Brass

	Per cent
Copper	59 to 63
Zinc	35.5 to 40.5
Tin	0.5 to 1.5
Iron	0.06*
Lead	0.60*

Phosphor Bronze

	Per cent
Copper	80 to 90
Tin	6 to 8
Zinc	2 to 14
Phosphorus	0.30
Iron	0.06*
Lead	0.20*

*Maximum.

COMPOSITIONS OF NONFERROUS ALLOYS
(Concluded)

COMPOSITION FOR BRASS SCREW PIPE FITTINGS

	Per cent
Copper	77 to 80
Zinc	13 to 19
Tin	4.0
Iron	0.10*
Lead	3.00*

THRUST RINGS

	Per cent
Copper	82 to 84
Tin	12.5 to 14.5
Lead	2.5 to 4.5

MONEL METAL INGOTS

	Per cent
Nickel	60
Copper	38
Manganese	2

Small percentages of other ingredients will be permitted in Monel metal ingots provided that they do not affect the casting qualities or are detrimental to the strength or non-corrosive properties of the metal.

ALUMINUM ALLOYS

An aluminum alloy known as "Partenium," and named after its inventor, G. H. Partin, follows:

	Per cent
Copper	78
Tin	20
White arsenic	2

Melt the copper under charcoal, and when liquid throw the arsenic, which has been previously wrapped in paper, onto the surface of the copper and when thoroughly heated stir into the metal. Pour the alloy into ingots and afterwards break up as fine as possible and mix with 1 per cent tungsten and 3 per cent of pulverized antimony. This mixture is again remelted and afterwards poured into ingots and forms the hardening alloy, which is used as follows:

	Per cent
Aluminum	96
Hardening alloy	4

To make the alloy, first melt a portion of the aluminum, heat until a deep red, and add the hardening alloy; when dissolved, charge the remainder of the aluminum.

*Maximum.

COMPOSITIONS OF NONFERROUS ALLOYS
(Concluded)

For the purpose of securing uniformity in the quality of castings for use on naval vessels the following standard requirements for special alloys have been issued by the bureau of construction and repair of the United States navy department:

MANGANESE BRONZE

	Per Cent
Copper	56.00
Zinc	41.38
Iron	1.25
Tin	0.75
Aluminum	0.50
Manganese	0.12

This alloy is used for the turning gear of turrets, the main gearing of the steering engine and other castings requiring great strength. The castings must be sound, clean, free from blow holes, porous spots, cracks or any other defects. Individual test pieces are required for castings weighing over 200 pounds, while castings of less weight are tested by lots.

The test pieces shall show an ultimate tensile strength of not less than 60,000 pounds per square inch, an elastic limit of not less than 30,000 per square inch, and an elongation of not less than 20 per cent in two inches. The color of the fractured section of the test pieces, and the grain of the metal must be uniform throughout.

TOBIN BRONZE

	Per Cent
Copper	59.00
Zinc	38.40
Tin	2.20
Lead	0.30
Iron	0.10

Tobin bronze is most frequently used in the rolled condition, for purposes where great strength is required or in cases where the alloy is subject to corrosion by salt water.

MUNTZ METAL

	Per Cent
Copper	60.00
Zinc	40.00

This alloy is used for bolts and nuts that are subjected to the action of salt water.

ANTI-FRICTION METAL

	Per Cent
Banca tin	88.80
Regulus of antimony	7.50
Best refined copper	3.70

This alloy is used for all white metal lined bearings, and bearing surfaces. When practicable, the weighing and mixing of the metals comprising this alloy will be witnessed by a government inspector. Otherwise, as many chemical analyses will be taken as may be necessary to show that the alloy is of the proper composition.

PICKLING SOLUTIONS FOR BRASS

Roseleur's Dip

For removing sand from brass and bronze castings the following dip, known as Roseleur's dip, is much used:

	Gallons
Muriatic acid	6
Old aqua fortis (nitric acid)	1
Water	2

Submerge the castings and leave in the acid for a half hour, or more if required to loosen the sand. Then remove and rinse and submerge in the following bright dip:

Yellow aqua fortis, 36 degrees	1 gallon
Sulphuric acid, 66 degrees	1 gallon
Common salt	1 ounce

Mix this solution a day or two before using to allow it to cool. Add the sulphuric acid to the nitric acid, and lastly the salt. If the action is too rapid, add more sulphuric acid. The aqua fortis or nitric acid should be yellow in color, and the dip is spent when it works slow, or when the castings have a bluish white film .

Fumeless Bright Dip

In place of the above bright dip, the following dip known as the fumeless bright dip may be used:

	Pounds
Sulphuric acid	10
Saltpeter	2
Water	5

Dissolve the saltpeter in the water, and add the sulphuric acid gradually, in a thin stream, stirring continually with a glass rod. The water will get very hot, and time may be allowed for it to cool before all the acid is added. Do not use the dip until it has become almost cold.

After the castings are dipped they should be rinsed in cold water, then in hot water containing some whale oil or fig soap in the proportions of one ounce of soap to one gallon of water. The castings are then allowed to dry off naturally as a thin film of soap dries on and protects them against oxidation.

SECTION V

SPECIFICATIONS

SPECIFICATIONS FOR GRAY-IRON CASTINGS

1. These specifications cover three classes of gray-iron castings, as follows:
(a) LIGHT CASTINGS, those having any section less than ½ inch in thickness;
(b) HEAVY CASTINGS, those in which no section is less than 2 inches in thickness;
(c) MEDIUM CASTINGS, those not included in either of the above two classes.

2. The tension test will be made only when specified by the purchaser and at his expense.*

I—MANUFACTURE

3. The castings shall be made by the cupola process, unless furnace iron is specified.

II—CHEMICAL PROPERTIES AND TESTS

4. (a) Drillings taken from the fractured end of the transverse test bars shall conform to the following requirements as to sulphur:

Light castings	not over 0.10 per cent
Medium castings	not over 0.10 per cent
Heavy castings	not over 0.12 per cent

(b) One sulphur determination shall be made for each mold of test bars cast, in accordance with the standard methods for sampling and analysis of pig and cast iron (serial designation: A64) of the American Society for Testing Materials. In case of dispute, the standards of the U. S. bureau of standards shall be used for comparison.

III—PHYSICAL PROPERTIES AND TESTS

5. (a) The transverse test specimens (arbitration test bars) specified in section 7 (a), when placed horizontally upon supports 12 inches apart and tested under a centrally applied load, shall conform to the following minimum requirements, interpreted in accordance with section 9:

	Class of Casting		
	Light	Medium	Heavy
Load at center, lb.	2500	2900	3300
Deflection at center, in.	0.10	0.10	0.10

(b) The rate of application of the load shall be such that a central deflection of 0.10 inch is produced in from 20–40 seconds.

Adopted as standard by the American Society for Testing Materials, 1918.

*It is recommended by committee A-3 on cast iron that the tension test shall not be made, for the reason that cast iron is almost devoid of elasticity, and hence any deviation from an absolutely straight pull in commercial testing machines yields defective results.

SPECIFICATIONS FOR GRAY-IRON CASTINGS
(Continued)

6. When tension tests are specified, the tension test specimen shall conform to the following minimum requirements as to tensile strength:

Light castings	18,000 lb. per sq. in.
Medium castings	21,000 lb. per sq. in.
Heavy castings	24,000 lb. per sq. in.

7. (a) ARBITRATION TEST BAR—The form and dimensions of the mold for the arbitration test bar shall be in accordance with Fig. 1. The bottom of the bar shall be 1/16 inch smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask shall be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8

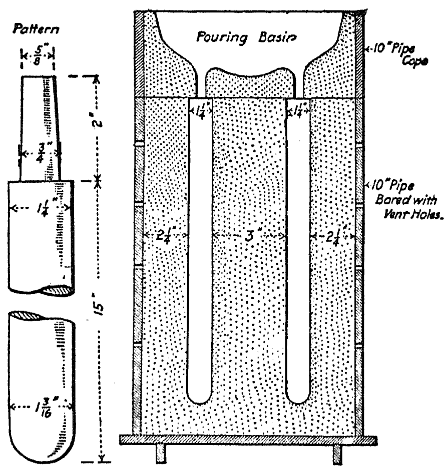


FIG. 1—ARBITRATION TEST BARS

sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried, and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

(b) TENSION TEST SPECIMEN—When tension tests are specified, the tension test specimen shall be turned from any of the broken pieces of the transverse test specimens, and shall conform to the dimensions shown in Fig. 2.

SPECIFICATIONS FOR GRAY-IRON CASTINGS
(Concluded)

8. (a) Two sets of two arbitration test bars each shall be cast from each melt, one set from the first and the other set from the last iron going into the castings. Where the melt exceeds 20 tons, an additional set of two bars shall be cast for each additional 20 tons or fraction thereof. In case of a change of mixture during the melt, one set of two bars shall also be cast for every mixture other than the regular one. Each set of two bars shall be cast in a single mold.

(b) All arbitration test bars cast shall be tested as specified in section 5 (a).

9. One arbitration test bar of each set cast shall conform to the requirements specified in section 5 (a); otherwise the castings represented by such bars shall be rejected.

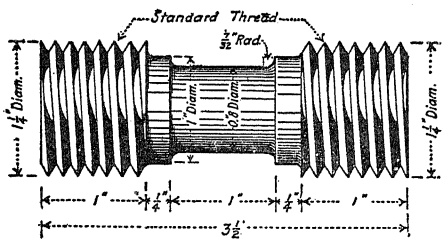


Fig. 2—Tension Test Specimen

IV—Workmanship and Finish

10. The castings shall be true to pattern, and free from cracks, flaws and excessive shrinkage. In other respects they shall conform to whatever points may be specially agreed upon between the manufacturer and the purchaser.

V—Inspection

1. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspections shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

SPECIFICATIONS FOR CAST-IRON SOIL PIPE AND FITTINGS

I—Manufacture

1. The cast iron from which the pipe and fittings are made shall be of such composition, and the conditions of manufacture so maintained, that the castings will be of uniform physical character, close-grain, and not hard, brittle nor difficult to cut with file or chisel.

2. (a) When pipe or fittings are to be coated, coal-tar pitch shall be used, which shall contain sufficient oil to make a smooth coating. The pitch shall be tough and tenacious when cold, and not brittle nor having any tendency to scale.

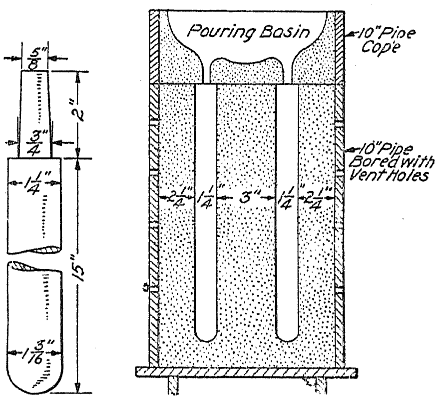


FIG. 1—ARBITRATION TEST BARS

(b) The varnish shall be heated to about 300 degrees Fahr. and shall remain at this temperature during the time the casting is immersed.

(c) Each casting shall be heated to a uniform temperature of about 300 degrees Fahr. immediately before it is dipped, and shall possess this temperature at the time it is put in the bath.

(d) Each casting shall remain in the bath at least two minutes.

(e) Fresh pitch and oil shall be added when necessary to keep the mixture of the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch whenever the accumulation of sand or carbonaceous matter renders this desirable, as can be seen by the solids adhering to the under side or lower ends of the castings.

(f) After being coated, the pipe and fittings shall be carefully drained of the surplus varnish.

II—Chemical Properties and Tests

3. Drillings taken from the fractured end of the arbitration test bar shall not contain over 0.10 per cent of sulphur.

Adopted by the American Society for Testing Materials, 1918.

SPECIFICATIONS FOR CAST-IRON SOIL PIPE AND FITTINGS

(Continued)

III—Physical Properties and Tests

4. The transverse test specimens (arbitration test bars) specified in section 7, when placed horizontally upon supports 12 inches apart and tested under a centrally applied load, shall conform to the following minimum requirements:

AVERAGE LOAD AT CENTER, LB.	2500
AVERAGE DEFLECTION AT CENTER, IN.	0.10

5. All pipe shall be tested to a hydrostatic pressure of not less than 50 pounds per square inch before coating. Any casting showing defects under this hydrostatic test shall be promptly broken and returned to the cupola.

6. The form and dimensions of the mold for the arbitration test bar shall be in accordance with Fig. 1. The bottom of the bar shall be 1/16-inch smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask shall be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried, and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

7. From each melt of metal not less than three test specimens (arbitration test bars) shall be poured, the first of which shall be poured within five minutes after the first ladle is tapped and the remainder at intervals not exceeding one hour throughout the melt.

IV—Standard Sizes and Weights

8. (a) The inside diameter of the barrel of any pipe or fittings or branch thereof shall not vary more than ⅛-inch under the nominal size of pipe.

(b) The outside diameter of the barrel of pipe and fittings shall be ½-inch greater than its nominal inside diameter. A variation in the outside diameter of ⅛-inch over or under these figures will be permitted.

Table I

WEIGHT OF SOIL PIPE

Size in.	Single Hub Per 5-ft. Length, pound	Per ft. including Hub, pound	Double Hub Per 5-ft. Length, pound
2	27½	5½	27½
3	47½	9½	47½
4	65	13	65
5	85	17	85
6	100	20	100

SPECIFICATIONS FOR CAST-IRON SOIL PIPE AND FITTINGS
(Continued)

Table II

WEIGHT OF SOIL PIPE FITTINGS

Only the staple fittings are shown. From the data herewith the weights of other fittings may be calculated. All values are in pounds.

	Size of Fittings, Inches														
	2	3	4	5	6	3 by 2	4 by 2	4 by 3	5 by 2	5 by 3	5 by 4	6 by 2	6 by 3	6 by 4	6 by 5
¼ Bends, regular	6¾	10¼	15	19	23½										
¼ Bends, short sweep	8¼	12½	17¾	22½	27½										
¼ Bends, long sweep	10¼	15¾	22	27½	33½										
⅕ Bends	6¼	9¾	13¾	17½	21½										
⅙ Bends	6	9¼	13	16½	20										
⅛ Bends	5½	8½	12¼	15¼	18¼										
1/16 Bends	5	7¾	10¾	13¼	15¾										
Return Bends	8¾	14	20¼	26½	33½										
Tees	10¼	15¼	21	26½	32½	13¼	16½	18¾	19¼	22	24½	22½	25	27½	30
Tapped Tees (tapped up to 2 in.)	8¾					11¾	15		17¾			20½			
Sanitary Tees	11	16¼	22½	28	34½	14	17¼	19¾	20	23	25½	23	26	29	31½
Tapped Sanitary Tees (tapped up to 2 in.)	9					12	15¼		18			21¼			
Y Branch	11	17	24	31½	39½	14	17¼	20½	20	23½	27½	23	27	31	35
½ Y Branch	10¼	15½	21½	27½	34	13½	16½	19	19½	22	25	22½	25½	28½	31
Tapped Inverted Y Branch (tapped up to 2 in.)	10¼	13¾	17½	21	24										
Inverted Y Branch	11½	18	25½	33	41½	15	18¾	22	22	25½	29½	25½	29½	33	37
Combination Y and ⅛ Bend	12	18¾	27	35	44½	15	18¼	22½	21	25½	30½	24	29	34	39
Upright Y Branch	12½	19½	28	36½	46	15¾	18¾	23	21½	26½	31½	24½	29½	35	40

SPECIFICATIONS FOR CAST-IRON SOIL PIPE AND FITTINGS
(Concluded)

(c) All pipe and fittings shall be of uniform thickness of wall and present true circles at the hub and spigot ends. A variation of 1/16-inch under the following dimensions will be permitted, but only when the actual weight is not less than the variation of the marked or estimated weight as given in tables I and II:

THICKNESS OF BARREL	¼ inch
THICKNESS OF BODY OF HUB	5/16 inch
THICKNESS OF BEAD OF HUB	½ inch
THICKNESS OF BEAD OF SPIGOT END	7/16 inch

9. (a) Weights and measurements of pipe and fittings shall be taken as those of plain uncoated pipe. All weights shall be given in pounds.

(b) Individual lengths of pipe and fittings may weigh five per cent less than designated in Tables I and II, but only when the average weight of a given size and weight of pipe and fittings selected at random is not less than that shown in Tables I and II.

(c) The regular length of pipe shall be such as to lay five feet including hub.

(d) The average weights of soil pipe and fittings shall not be less than those given in Tables 1 and II.

V—Workmanship and Finish

10 (a) All pipe and fittings shall be practically straight and cylindrical and fittings true to pattern. The specified sizes shall be for the inside diameter and shall conform, within the allowable variation, to the dimensions given in the tables.

(b) All pipe and fittings shall be carefully examined for defects and sounded with a hammer before shipment. No fillings with metal, cement or other material, or so-called "burning on" of iron will be permitted. The castings shall be sound and free from cracks, sand holes, blow-holes and cold-shots.

VI—Marking

11. All pipe and fittings shall be marked with the name of the manufacturer, or appropriate initial. Each casting shall have cast upon it the minimum or estimated weight of the same as shown in Tables I and II.

VII—Inspection and Rejection

12. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works and shall be made prior to shipment, unless otherwise specified.

13. All pipe and fittings which fail to conform to the provisions of these specifications shall be subject to rejection.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDERS

1.—Locomotive cylinders shall be made from good quality, close grained gray iron cast in a dry mold.

CHEMICAL PROPERTIES AND TESTS

2.—Drillings taken from the fractured end of the transverse test bars shall conform to the following limits in chemical composition:

Phosphorus .... not over 0.90 per cent
Sulphur .... not over 0.12 per cent

3.—A check analysis of drillings taken from the transverse test bar may be made by the purchaser, and shall conform to the requirements specified in Section 2.

PHYSICAL PROPERTIES AND TESTS

4.—When placed horizontally upon supports 12 inches apart and tested under a centrally applied load, the arbitration test bars, specified in Section 6 (*a*), shall show an average transverse strength of not less

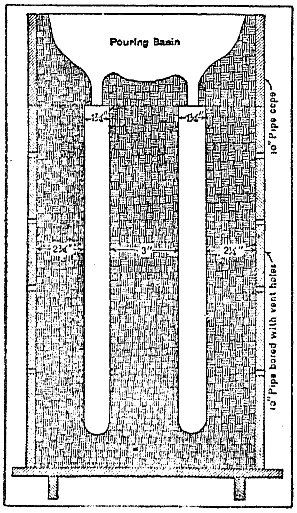


FIG. 1.—MOLD FOR ARBITRATION TEST BAR

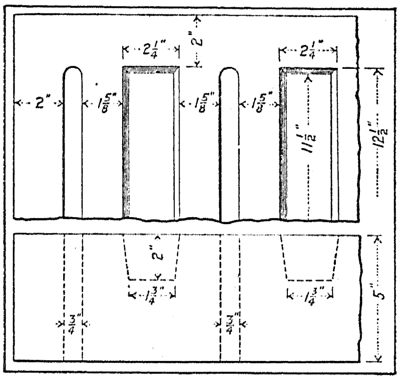


FIG. 2.—MOLD FOR CHILL TEST SPECIMEN

than 3200 pounds and an average deflection of not less than 0.09 inch.

5.—Before pouring, a sample of the iron shall be taken and chilled in a cast-iron mold, as specified in Section 6 (*b*). The sample shall be allowed to cool in the mold until it is dark red or almost black, when it may be knocked out and quenched in water. The sample, on being broken, must show a close grained gray iron, with a well-defined border of white iron at the bottom of the fracture. The depth of the white iron must not be less than 1-16 inch as measured at the center line.

Adopted by the American Society for Testing Materials, 1914.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDERS
(*Concluded*)

6—(*a*) *Arbitration Bar.*—The mold for the bars is shown in Fig. 1. The bottom of the bar is 1-16 inch smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply brushed off before testing.

(*b*) *Chill Test.*—The form and dimensions of the mold shall be in accordance with Fig. 2.

7—(*a*) Two arbitration test bars, cast as specified in Section 6 (*a*), shall be poured from each ladle of metal used for one or more cylinders.

(*b*) One chill test, cast as specified in Section 6 (*b*), shall be poured from each ladle of metal used for one or more cylinders. The chill specimens may be cast in adjacent molds, but in such cases a space must be provided between the molds. (See Fig. 2).

Workmanship and Finish

8—Cylinders shall be smooth, well cleaned, free from shrinkage cracks and from other defects sufficiently extensive to impair the value of the castings, and shall finish to blueprint size.

Marking

9—Each cylinder shall have cast on it, in raised letters, marks designating the maker, the date of casting, the serial and pattern numbers and other marks specified by the purchaser.

Inspection and Rejection

10.—(*a*) The purchaser or his inspector shall be given a reasonable opportunity to enable him to witness the pouring of the cylinders and test specimens, as well as to be present when physical tests are made.

(*b*) In case the inspector is not present to witness the pouring of the castings and test specimens, the manufacturer will make all tests required by the specification, and, upon demand, will furnish the purchaser with a copy of the results of his tests, and will hold the transverse and chill test specimens subject to examination by the inspector. The tests made by the manufacturer shall be considered final.

(*c*) All physical tests and inspection shall be made at the place of manufacture.

11.—Unless otherwise specified, any rejection based on tests made in accordance with Section 3, shall be reported within five working days from the receipt of samples.

SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS

Description of Pipes

The pipes shall be made with hub and spigot joints, and shall accurately conform to the dimensions given in tables Nos. 1 and 2. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 feet in length, exclusive of socket. For pipes of each size from 4-inch to 24-inch, inclusive, there shall be two standards of outside diameter, and for pipes from 30-inch to 60-inch, inclusive, there shall be four standards of outside diameter, as shown by table No. 2.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of about 6 inches from each end of the pipe so as to obtain the required standard thickness and weight for each size and class of pipe.

Pipes whose standard thickness and weight are intermediate between the classes in table No. 2 shall be made of the same outside diameter as the next heavier class. Pipes whose standard thickness and weight are less than shown by table No. 2 shall be made of the same outside diameter as the class A pipes, and pipes whose thickness and weight are more than shown by table No. 2 shall be made of the same outside diameter as the class D pipes.

For pipes 4-inch to 12-inch, inclusive, one class of special castings shall be furnished made from class D pattern. Those having spigot ends shall have outside diameters of spigot ends midway between the two standards of outside diameter as shown by table No. 2, and shall be tapered back for a distance of 6 inches. For pipes from 14-inch to 24-inch, inclusive, two classes of special castings shall be furnished, class B special castings with classes A and B pipes, and class D special castings with classes C and D pipes, the former to be stamped "AB" and the latter to be stamped "CD." For pipes 30-inch to 60-inch, inclusive, four classes of special castings shall be furnished, one for each class of pipe, and shall be stamped with the letter of the class to which they belong.

Allowable Variation in Diameter of Pipes and Sockets

Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gages, and no pipe will be received which is defective in joint room, from any cause. The diameters of the sockets and the outside diameters of the bead ends of the pipes shall not vary from the standard dimensions by more than 0.06 of an inch for pipes 16 inches or less in diameter; 0.08 of an inch for 18-inch, 20-inch and 24-inch pipes; 0.10 of an inch for 30-inch, 36-inch and 42-inch pipes; 0.12 of an inch for 48-inch, and 0.15 of an inch for 54-inch and 60-inch pipes.

Adopted as standard by the American Society for Testing Materials, 1904.

SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS
(Continued)

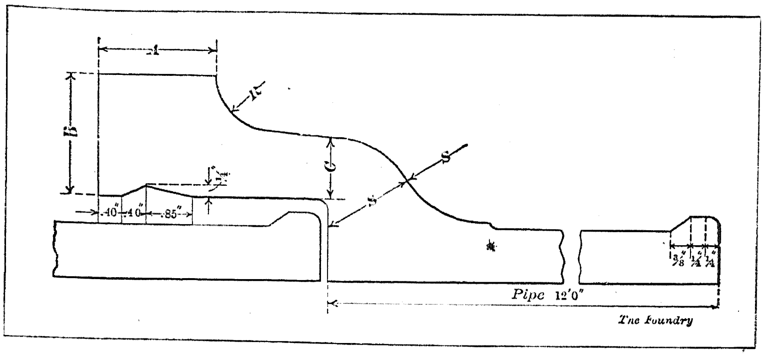


Table 1—General Dimensions of Pipe

Nominal Diam. Inches.	Classes.	Actual Outside Diam. Inches.	Diameter of Sockets: Pipe. Inches.	Diameter of Sockets: Special Castings. Inches.	Depth of Sockets: Pipe. Inches.	Depth of Sockets: Special Castings. Inches.	A	B	C
4	A—B	4.80	5.60	5.70	3.50	4.00	1.5	1.30	0.65
4	C—D	5.00	5.80	5.70	3.50	4.00	1.5	1.30	0.65
6	A—B	6.90	7.70	7.80	3.50	4.00	1.5	1.40	0.70
6	C—D	7.10	7.90	7.80	3.50	4.00	1.5	1.40	0.70
8		9.05	9.85	10.00	4.00	4.00	1.5	1.50	0.75
8	C—D	9.30	10.10	10.00	4.00	4.00	1.5	1.50	0.75
10	A—B	11.10	11.90	12.10	4.00	4.00	1.5	1.50	0.75
10	C—D	11.40	12.20	12.10	4.00	4.00	1.5	1.60	0.80
12	A—B	13.20	14.00	14.20	4.00	4.00	1.5	1.60	0.80
12	C—D	13.50	14.30	14.20	4.00	4.00	1.5	1.70	0.85
14	A—B	15.30	16.10	16.10	4.00	4.00	1.5	1.70	0.85
14	C—D	15.65	16.45	16.45	4.00	4.00	1.5	1.80	0.90
16	A—B	17.40	18.40	18.40	4.00	4.00	1.75	1.80	0.90
16	C—	17.80	18.80	18.80	4.00	4.00	1.75	1.90	1.00
18	A—B	19.50	20.50	20.50	4.00	4.00	1.75	1.90	0.95
18	C—D	19.92	20.92	20.92	4.00	4.00	1.75	2.10	1.05
20	A—B	21.60	22.60	22.60	4.00	4.00	1.75	2.00	1.00
20	C—D	22.06	23.06	23.06	4.00	4.00	1.75	2.30	1.15
24	A—B	25.80	26.80	26.80	4.00	4.00	2.00	2.10	1.05
24	C—D	26.32	27.32	27.32	4.00	4.00	2.00	2.50	1.25
30	A	31.74	32.74	32.74	4.50	4.50	2.00	2.50	1.15
30	B	32.00	33.00	33.00	4.50	4.50	2.00	2.30	1.15
30	C	32.40	33.40	33.40	4.50	4.50	2.00	2.60	1.32
30	D	32.74	33.74	33.74	4.50	4.50	2.00	3.00	1.50
36	A	37.96	38.96	38.96	4.50	4.50	2.00	2.50	1.25
36	B	38.30	39.30	39.30	4.50	4.50	2.00	2.80	1.40
36	C	38.70	39.70	39.70	4.50	4.50	2.00	3.10	1.60
36	D	39.16	40.16	40.16	4.50	4.50	2.00	3.40	1.80
42	A	44.20	45.20	45.20	5.00	5.00	2.00	2.80	1.40
42	B	44.50	45.50	45.50	5.00	5.00	2.00	3.00	1.50
42	C	45.10	46.10	46.10	5.00	5.00	2.00	3.40	1.75
42	D	45.58	46.58	46.58	5.00	5.00	2.00	3.80	1.95
48	A	50.50	51.50	51.50	5.00	5.00	2.00	3.00	1.50
48	B	50.80	51.80	51.80	5.00	5.00	2.00	3.30	1.65
48	C	51.40	52.40	52.40	5.00	5.00	2.00	3.80	1.95
48	D	51.98	52.98	52.98	5.00	5.00	2.00	4.20	2.20
54	A	56.66	57.66	57.66	5.50	5.50	2.25	3.20	1.60
54	B	57.10	58.10	58.10	5.50	5.50	2.25	3.60	1.80
54	C	57.80	58.80	58.80	5.50	5.50	2.25	4.00	2.15
54	D	58.40	59.40	59.40	5.50	5.50	2.25	4.40	2.45
60	A	62.80	63.80	63.80	5.50	5.50	2.25	3.40	1.70
60	B	63.40	64.40	64.40	5.50	5.50	2.25	3.70	1.90
60	C	64.20	65.20	65.20	5.50	5.50	2.25	4.20	2.25
60	D	64.82	65.82	65.82	5.50	5.50	2.25	4.70	2.60

SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS

(Continued)

TABLE 2

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON PIPE

Nominal Inside Diam. Inches.	Class A. 100 Ft. Head. 43 Lbs. Pressure.			Class B. 200 Ft. Head. 86 Lbs. Pressure.			Class C. 300 Ft. Head. 130 Lbs. Pressure.			Class D. 400 Ft. Head. 173 Lbs. Pressure.			Nominal Inside Diam. Inches.
	Thickness. Inches.	Weight per Foot.	Weight per Length.	Thickness. Inches.	Weight per Foot.	Weight per Length.	Thickness. Inches.	Weight per Foot.	Weight per Length.	Thickness. Inches.	Weight per Foot.	Weight per Length.	
4	0.42	20.0	240	0.45	21.7	260	0.48	23.3	280	0.52	25.0	300	4
6	0.44	30.8	370	0.48	33.3	400	0.51	35.8	430	0.55	38.3	460	6
8	0.46	42.9	515	0.51	47.5	570	0.56	52.1	625	0.60	55.8	670	8
10	0.50	57.1	685	0.57	63.8	765	0.62	70.8	850	0.68	76.7	920	10
12	0.54	72.5	870	0.62	82.1	985	0.68	91.7	1,100	0.75	100.0	1,200	12
14	0.57	89.6	1,075	0.66	102.5	1,230	0.74	116.7	1,400	0.82	129.2	1,550	14
16	0.60	108.3	1,300	0.70	125.0	1,500	0.80	143.8	1,725	0.89	158.3	1,900	16
18	0.64	129.2	1,550	0.75	150.0	1,800	0.87	175.0	2,100	0.96	191.7	2,300	18
20	0.67	150.0	1,800	0.80	175.0	2,100	0.92	208.3	2,500	1.03	229.2	2,750	20
24	0.76	204.2	2,450	0.89	233.3	2,800	1.04	279.2	3,350	1.16	306.7	3,680	24
30	0.88	291.7	3,500	1.03	333.3	4,000	1.20	400.0	4,800	1.37	450.0	5.400	30
36	0.99	391.7	4,700	1.15	454.2	5,450	1.36	545.8	6,550	1.58	625.0	7,500	36
42	1.10	512.5	6,150	1.28	591.7	7,100	1.54	716.7	8,600	1.78	825.0	9,900	42
48	1.26	666.7	8,000	1.42	750.0	9,000	1.71	908.3	10,900	1.96	1,050.0	12,600	48
54	1.35	800.0	9,600	1.55	933.3	11,200	1.90	1,141.7	13,700	2.23	1,341.7	16,100	54
60	1.39	916.7	11,000	1.67	1,104.2	13,250	2.00	1,341.7	16,100	2.38	1.583.3	19,000	60

The above weights are for 12 feet laying lengths and standard sockets; proportionate allowance to be made for any variation therefrom.

Allowable Variation in Thickness

For pipes whose standard thickness is less than 1 inch the thickness of metal in the body of the pipe shall not be more than 0.08 of an inch less than the standard thickness, and for pipes whose standard thickness is 1 inch or more, the variation shall not exceed 0.10 of an inch, except that for spaces not exceeding 8 inches in length in any direction, variations from the standard thickness of 0.02 of an inch in excess of the allowance above given shall be permitted.

For special castings of standard patterns a variation of 50 per cent greater than allowed for straight pipe shall be permitted.

Defective Spigots May be Cut

Defective spigot ends on pipes 12 inches or more in diameter may be cut off in a lathe and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 feet in length, exclusive of the socket.

In case the length of a pipe differs from 12 feet, the standard weight of the pipe given in table No. 2 shall be modified in accordance therewith.

Special Castings

All special castings shall be made in accordance with the cuts and the dimensions given in the table forming a part of these specifications.

The diameters of the sockets and the external diameters of the bead ends of the special castings shall not vary from the standard

SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS
(Continued)

dimensions by more than 0.12 of an inch for castings 16 inches or less in diameter; 0.15 of an inch for 18-inch, 20-inch and 24-inch; 0.20 of an inch for 30-inch, 36-inch and 42-inch, and 0.24 of an inch for 48-inch, 54-inch and 60-inch. These variations apply only to special castings made from standard patterns.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the size given in the tables. The manufacturer shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans and made of the best quality of mild steel, with hexagonal heads and nuts and sound, well-fitting threads.

Marking

Every pipe and special casting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe and special casting larger than 4-inch may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1901	1901	1901
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall be not less than 2 inches in length and ⅛ of an inch in relief for pipes 8 inches in diameter and larger. For smaller sizes of pipes the letters may be 1-inch in length. The weight and the class letter shall be conspicuously painted in white on the inside of each pipe and special casting after the coating has become hard.

Allowable Percentage of Variation in Weight

No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipes 16 inches or less in diameter, and 4 per cent for pipes more than 16 inches in diameter, and no excess above the standard weight of more than the given percentages for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more that 2 per cent.

No special casting shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent for pipes 12 inches or less in diameter, and 8 per cent for larger sizes, except that curves, Y pieces and breeches pipe may be 12 per cent below the standard weight, and no excess above the standard weight of more than the above percentages for the several sizes will be paid for. These variations apply only to castings made from the standard patterns.

Quality of Iron

All pipes and special castings shall be made of cast iron of good quality, and of such character as shall make the metal of the casting strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS

(*Continued*)

Tests of Material

Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct, and, in default of definite instructions, the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall for pipes 12 inches or less in diameter support a load of 1,900 pounds and show a deflection of not less than 0.30 of an inch before breaking, and for pipes of sizes larger than 12 inches shall support a load of 2,000 pounds and show a deflection of not less than 0.32 of an inch. The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

Casting of Pipes

The straight pipes shall be cast in dry sand molds in a vertical position. Pipes 16 inches or less in diameter shall be cast with the hub end up or down, as specified in the proposal. Pipes 18 inches or more in diameter shall be cast with the hub end down.

The pipes shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Quality of Castings

The pipes and special castings shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

Cleaning and Inspection

All pipes and special castings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

Coating

Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahr. immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 degrees Fahr. (or less if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be recoated shall first be thoroughly scraped and cleaned.

Hydrostatic Test

When the coating has become hard, the straight pipes shall be subjected to a

SPECIFICATIONS FOR CAST-IRON PIPE AND SPECIAL CASTINGS

(Concluded)

proof by hydrostatic pressure and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipes shall be subjected are as follows:

	20-inch diameter and larger. Pounds per sq. in.	Less than 20-inch diameter. Pounds per sq. in.
Class A Pipe.....	150	300
Class B Pipe.....	200	300
Class C Pipe.....	250	300
Class D Pipe.....	300	300

WEIGHING

The pipes and special castings shall be weighed for payment under the supervision of the engineer after the application of the coal-tar pitch varnish. If desired by the engineer, the pipes and special castings shall be weighed after their delivery and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 pounds.

CONTRACTOR TO FURNISH MEN AND MATERIALS

The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipes and special castings; and, should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

POWER OF ENGINEER TO INSPECT

The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting and coating of the pipes and special castings. The forms, sizes, uniformity and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipes or other casting which is not in conformity with the specifications or drawings.

INSPECTOR TO REPORT

The inspector at the foundry shall report daily to the foundry office all pipes and special castings rejected, with the causes for rejection.

CASTINGS TO BE DELIVERED SOUND AND PERFECT

All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other castings which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered until the final completion and adjustment of the contract, provided, however, that the contractor shall not be held liable for pipes or special castings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they receive the coating.

DEFINITION OF THE WORD "ENGINEER"

Wherever the word "engineer" is used herein it shall be understood to refer to the engineer or inspector acting for the purchaser and to his properly authorized agents, limited by the particular duties intrusted to them.

HEAT-TREATING CASE-HARDENED CARBON-STEEL OBJECTS

It is recommended that the following treatments be applied to case-hardened carbon-steel objects according to requirements:

1. When hardness of case only is desired and lack of toughness or even brittleness unimportant, the carburized objects may be quenched from the carburizing temperature, as for instance, by emptying the contents of the boxes in cold water or in oil. Both the core and the case are then coarsely crystallin.

2. In order to reduce the hardening stresses and to decrease the danger of distortion and cracking in the quenching bath, the objects may be removed from the box and allowed to cool before quenching to a temperature slightly exceeding the critical range of the case, namely, 800 to 825 degrees Cent. Both the core and case remain coarsely crystallin.

3. To refine the case and increase its toughness, the carburized objects should be allowed to cool slowly in the carburized box within the furnace or outside to 650 degrees Cent. or below, and should then be reheated to a temperature slightly exceeding the lower critical point of the case (in the majority of instances a temperature varying in accordance with the carbon content and thickness of the case between 775 and 825 degrees Cent. will be suitable), and quenched in water, or, for greater toughness but less hardness, in oil. The objects should be removed from the quenching bath before their temperature has fallen below 100 degrees Cent. This treatment is more especially to be recommended when the carburizing temperature has not exceeded 900 degrees Cent. It refines the case but not the core.

4. To refine both the core and the case and to increase their toughness, the objects should be allowed to cool slowly from the carburizing temperature to 650 degrees Cent. or below and should then be (a) reheated to a temperature exceeding the critical point of the core, which will generally be from 900 to 950 degrees Cent., followed by quenching in water or in oil; and (b) before they have cooled below 100 degrees Cent., they should be reheated to a temperature slightly exceeding the lower critical point of the case (in the majority of instances a temperature varying in accordance with the carbon content and thickness of the case between 775 and 825 degrees Cent. will be suitable), and again quenched in water or oil.

Adopted as recommended practice by the American Society for Testing Materials, 1914.

ANNEALING CARBON-STEEL CASTINGS

1. The castings should preferably be sufficiently cleaned of adhering sand before annealing to insure thorough and uniform heating.

2. The castings should be heated slowly and uniform to temperatures varying with the carbon content of the steel, approximately as follows:

Carbon per cent	Temperature degrees Cent
Up to 0.16	925
0.16 to 0.34	875
0.35 to 0.54	850
0.55 to 0.79	830

Nothing in these recommendations shall operate against the temperatures aimed at being 50, and in special cases, 100 degrees Cent. higher than those given in the table, when necessary to attain the the desired result.

3. The castings should be kept at a maximum temperature a sufficient length of time to insure the refining of the grain. In general, the heavier the sections of the casting, the longer must be the time of exposure to the maximum temperature.

4. (a) The castings should be cooled slowly and uniformly in the furnace, when it is desired that the steel shall possess the maximum softness.

(b) The castings may be cooled at an accelerated rate. when it is desired that the steel possess rather higher tensile strength and elastic limit than can be be procured by very slow cooling. This cooling must be so conducted as to leave the steel reasonably free from cooling stresses.

The manner of carrying out this accelerated cooling should be such as will attain the desired result. For instance, the castings may be withdrawn from the furnace and buried in a bed of material that is a poor conductor of heat; or the annealing furnace may be so thrown open that it will cool more rapidly than if left closed. Should the castings be of such uneven section that they cool at unequal rates at various points when the furnace is opened, especially if the carbon of the steel is high, the furnace should be closed after the castings have become black, and their further cooling so retarded that the stresses set up by the unequal rates of cooling are relieved.

Adopted as recommended practice by the American Society for Testing Materials, 1914.

SCRAP METAL SPECIFICATIONS

The specifications adopted by the National Association of Waste Material Dealers for scrap nonferrous metals are as follows:

Heavy Copper

Heavy copper shall consist of copper not less than $\frac{1}{16}$-inch thick, and may include trolley wire, heavy field wire, heavy armature wire that is not tangled; also new copper clippings and punchings, untinned and clean, and also copper segments that are clean.

No. 1 Copper Wire

No. 1 copper wire shall consist of clean, untinned copper wire not smaller than No. 16 B. and S. wire gage, to be free from burnt copper that is brittle, and all foreign substances.

No. 2 Copper Wire

No. 2 copper wire shall consist of miscellaneous clean copper wire such as of necessity would be sorted out of Heavy Copper wire and No. 1 Copper Wire, but to be free of hair wire and burnt wire which is brittle.

Light Copper

Light copper scrap shall consist of the bottoms of kettles and boilers, bath tub linings, hair wire, burnt copper wire which is brittle, roofing copper and similar copper; it should be free from visible iron, brass, lead and solder connections, old electrotype shells and should not contain excessive paint, tar and scale.

Cocks and Faucets

Cocks and faucets shall be mixed red and yellow brass scrap, free from gas cocks and beer faucets; this scrap should be at least half red brass.

Heavy Yellow Brass

Heavy yellow brass scrap shall consist of heavy brass castings, rolled brass, rod brass ends, brass screws and tinned or nickel-plated brass tubing; it should be free from iron and dirt and must be in pieces not too large for crucibles; no piece should measure more than 12 inches over any one part; also it must be free from aluminum and manganese mixtures. Condenser tubes shall not be considered as heavy brass.

SCRAP METAL SPECIFICATIONS
(Concluded)

Light Brass

Light brass scrap shall consist of light sheet brass, forks, spoons and miscellaneous brass that is too light for heavy work. It must be free from visible iron, gun shells containing paper, iron-loaded lamp bases and the works of clocks.

New Brass Clippings

New brass clippings shall consist of the cuttings of new sheet brass and must be absolutely clean and free from any foreign substance.

Brass Tubing

Brass scrap tubing shall consist of brass tubing free from nickelplating, tinning or soldering, or tubes with cast brass connections. Sound, clean tubes, free of sediment, and condenser tubes only should be accepted.

No. 1 Composition Turnings

No. 1 composition turnings shall be free from aluminum, manganese, plastic and yellow brass turnings and must not contain over 2 per cent iron. They should be free from grindings and other foreign material, especially babbitt and adulterations made to resemble metal. Turnings not according to this specification should be subject to sample.

No. 1 Yellow Brass Turnings

No. 1 yellow brass turnings shall consist of strictly rod turnings, free from aluminum, manganese, composition and tobin turnings. They should not contain over 3 per cent iron, oil, or other moisture and must be free from grindings and babbitts. To avoid dispute, they should be purchased subject to sample.

Composition or Red Brass

Composition or red brass scrap shall consist of red brass, valves, machinery bearings and other parts of machinery, including miscellaneous castings made of copper, tin, zinc, and (or) lead, no piece to measure more than 12 inches over any one part; it should be free from aluminum, manganese, railroad boxes, cocks and faucets, gates, pot pieces, ingots and burned brass.

Railroad Bearings

Railroad bearings shall consist of railroad boxes or car journal bearings classed as used standard scrap and free from yellow boxes and babbitt; excessive grease and dirt on this scrap should be cause for rejection.

SPECIFICATIONS FOR EXHAUST SYSTEMS

Specifications for the design, construction and operation of exhaust systems for grinding, polishing and buffing wheels, which can be advantageously applied by all manufacturers engaged in this work, have been adopted by the New York State Department of Labor. These specifications, prepared by William Newell, mechanical engineer of the department, were issued for the purpose of effecting the efficient removal of dust from grinding and buffing wheels. Their object is to prevent the construction of exhaust systems on faulty designs, such as making the main suction duct too small, and not infrequently, the same size throughout its length; running the branch pipes into the main at right angles and sometimes at the bottom of the main; the use of too small a fan, dust collector, etc. The result of this improper construction is that the suction is entirely inadequate to carry off the dust, which then clogs the ducts and spreads about the room, impairing the health of the workmen.

The specifications follow:

Minimum sizes of branch pipes allowed for different sizes of emery or other grinding wheels:

Diameter of Wheels.	Maximum Grinding Surface, Square Inches.	Minimum Diameter of Branch Pipe, Inches.
6 inches or less, not over 1 inch thick	19	3
7 to 9 inches, inclusive, not over 1½ inches thick	43	3½
10 to 16 inches, inclusive, not over 2 inches thick	101	4
17 to 19 inches, inclusive, not over 3 inches thick	180	4½
20 to 24 inches, inclusive, not over 4 inches thick	302	5
25 to 30 inches, inclusive, not over 5 inches thick	472	6

In case a wheel is thicker than given in the above tabulation, or if a disc instead of a regular wheel is used, it must have a branch pipe no smaller than is called for by its grinding surface.

Minimum sizes of branch pipes allowed for different sizes of buffing, polishing, or rag wheels:

Diameter of Wheels.	Maximum Grinding Surface, Square Inches.	Minimum Diameter of Branch Pipe, Inches.
6 inches or less, not over 1 inch thick	19	3½
7 to 12 inches, inclusive, not over 1½ inches thick	57	4
13 to 16 inches, inclusive, not over 2 inches thick	101	4½
17 to 20 inches, inclusive, not over 3 inches thick	189	5
21 to 24 inches, inclusive, not over 4 inches thick	302	5½
25 to 30 inches, inclusive, not over 5 inches thick	472	6½

Buffing wheels, 6 inches or less in diameter, used for jewelry work may have a 3-inch branch pipe.

The thickness given for buffing wheels applies to the thickness of the wheel at the center. In case the wheel is thicker than given in the above tabulation. it must have a branch pipe no smaller than is called for by its grinding surface.

SPECIFICATIONS FOR EXHAUST SYSTEMS
(Continued)

Branch pipes must be not less than the sizes specified, throughout their entire length.

All branch pipes must enter the main suction duct at an angle not exceeding 45 degrees and must incline in the direction of the air flow at junction with main.

Branch pipes must not project into main duct.

All laps in piping must be made in the direction of the air flow.

All bends, turns, or elbows, whether in main or branch pipes, must be made with a radius in the throat at least equal to 1½ times the diameter of the pipe on which they are connected.

The inlet of the fan or exhauster shall be at least 20 per cent greater in area than the sum of the areas of all the branch pipes and such increase shall be carried proportionately throughout the entire length of the main suction duct; that is, the area of the main at any point shall be at least 20 per cent greater than the combined areas of the branch pipes entering it between such point and the tail end or dead end of the system. If such increase is made greater than 20 per cent, the area of the main at any point, except that portion of it between the branch entering it nearest the fan and the fan, shall bear approximately the same ratio to the combined areas of the branches preceding that point; that is, between it and the tail end of the system, as the area of the main at the branch nearest the fan bears to the combined areas of all the branches. This provision is made to permit the use of a fan having a larger inlet area than the area of the main at the branch pipe nearest to the fan, is desired.

The area of the discharge pipe from the fan shall be as large or larger than the area of the fan inlet throughout its entire length.

The main trunk lines, both suction and discharge, shall be provided with suitable clean-out doors not over 10 feet apart and the end of the main suction duct shall be blanked off with a removable cap placed on the end.

Sufficient static suction head shall be maintained in each branch pipe within 1 foot of the hood to produce a difference of level of 2 inches of water between the two sides of a U-shaped tube. Test is to be made by placing one end of a rubber tube over a small hole made in pipe, the other end of the tube being connected to one side of U-shaped water gage. Test is to be made with all branch pipes open and unobstructed.

Recommendations

In addition to the foregoing specifications, which are compulsory in the state of New York, the following recommendations are made, which will result in more efficient operation and longer life of the system:

Emery and buffing wheel exhaust systems should be kept separate owing to danger of sparks from the former setting fire to the lint dust from the latter, if both are drawn into the same suction main.

SPECIFICATIONS FOR EXHAUST SYSTEMS
(Continued)

In the case of undershot wheels, that is, the top of the wheel runs toward the operator, which is almost always the direction of rotation of both emery and buffing wheels, the main suction duct should be back of and below the wheels and as close to them as is practicable; or it should be fastened to the ceiling of the floor below, preferably the former. If behind the wheels, it should be not less than 6 inches above the floor at every point to avoid possible charring of the floor in case of fire in the main duct and also to permit sweeping under it. For similar reasons it should be at least 6 inches below any ceiling it may run under.

Both the main suction and discharge pipes should be made as short and with as few bends as possible, to avoid loss by friction. If one or the other must be of considerable length, it is best to place the fan not far beyond where the nearest branch enters the large end of the main, as a long discharge main is a lesser evil than a long suction main.

Avoid any pockets or low places in ducts where dust might accumulate.

The main suction duct should be enlarged between every branch pipe entering it, whenever space permits, and in no case should the main duct receive more than two branches in a section of uniform area. All enlargements in the size of the main should be made on a taper and not by an abrupt change.

If there is a likelihood of a few additional wheels being installed, it is advisable to leave a space for them between the fan and the first branch and to put in an extra size fan. Or, a space may be left beyond the fan so that the fan may be moved along and the main extended when it is actually decided to install additional wheels, provided the fan is of sufficient size to still comply with these specifications after the additional branches are added.

Branch pipes should enter the main on the top or sides, but never at the bottom. Two branches should never enter a main directly opposite one another.

Each branch pipe should be equipped with a shut-off damper or blast gate, which may be closed, if desirable, when the wheel is not in use. Not more than 25 per cent of such blast gates should be closed at one time; otherwise, the air velocity in the main duct may drop too low and let the dust accumulate on the bottom.

It is important that the lower part of the hood shall come far enough forward beneath the front of the wheel so that the dust will enter the hood and not fall outside of it altogether, even if the accomplishment of this result necessitates leaving considerable space between the wheel and the lower part of the hood in order that the hood shall not interfere with the work.

Branch pipes should lead out of the hood as nearly as possible at the point where the dust will naturally be thrown into them by the wheels. This is important.

SPECIFICATIONS FOR EXHAUST SYSTEMS
(Continued)

An objectionable practice sometimes found where small work is polished is the use of a screen across the mouth of the branch pipe where it enters the hood. Such screens are an obstruction to the passage of material and the ravellings from buffing wheels are held against the screen by the suction, with the result that in a short time the draught is almost entirely cut off.

The use of a trap at the junction of the hood and branch pipe is good practice provided it is cleaned out regularly and not allowed to fill up with dust. This will catch the heavier particles and so take some wear off the fan. It will also serve to catch any nuts, pieces of tripoli, etc., dropped by accident, and in the case of work on small articles, will enable them to be recovered when dropped in the hood.

All bends, turns, or elbows, whether in main or branch pipes, should be made with a radius in the throat of twice the diameter of the pipe on which they are connected, wherever space permits.

Elbows should be made of metal one or two gages heavier than the pipe to which they are connected, as the wear on them is much greater than on the pipe.

The withdrawal of air from a room by an exhaust system naturally tends to create a slight vacuum and for this reason inlets for air at least equal to the sum of the areas of the branch pipes should be left open.

Recommendations for the size of the cyclone separator or dust collector are hard to give, as the separator must be proportioned to suit operating conditions, light dusts requiring a larger separator than heavy dusts. The table on page 271 is reproduced from the catalog of a prominent separator manufacturer, gives dimensions of separators stated to be suitable for metallic dusts and wood shavings. For such, it is stated, a separator should be selected the area of whose inlet is at least as large as the area of the discharge pipe from the fan. For light buffing dusts, lint, etc., the air outlet from the top of the separator should be so large that the velocity of discharge will not exceed 300 to 480 feet per minute; then select a separator of which the other dimensions are proportionate. The air outlet should be provided with a proper canopy or elbow to exclude the weather, but should be otherwise unobstructed. There should be ample clearance under the separator for the accumulation or storage of the dust which should never be allowed to pile up as high as the bottom of the separator.

SPECIFICATIONS FOR EXHAUST SYSTEMS
(*Continued*)

DUST SEPARATORS

The following table contains dimensions of separators suitable for metallic dusts and wood shavings:

Diameter of fan outlet, inches.	Area of fan outlet, square inches.	Openings in Separator. Size of inlet, inches.	Openings in Separator. Area of inlet, square inches.	Openings in Separator. Diameter of air outlet, inches.	Openings in Separator. Area of air outlet, square inches.	Openings in Separator. Diameter of dust outlet, inches.	Dimensions of Separator. Outside diameter of cylinder, inches.	Dimensions of Separator. Height of cylinder, inches.	Dimensions of Separator. Length of cone, inches.
5	20	2½ x 9	23	8½	56	3	29½	14	26½
6	28	3 x 10½	32	10	78	4	35½	15½	32½
7 or 8	38 or 50	3½ x 13	47	13	132	6	41½	18½	37½
9	63	4½ x 16	72	15	176	6	47½	21	43½
10	78	5 x 18	90	17	227	6	53½	23	50
11 or 12	95 or 113	5½ x 21	115	20	314	10	59½	26	56
13 or 14	133 or 154	6½ x 24	156	23½	433	10	65½	29	61½
15	177	7 x 27	189	26	531	10	71½	32	67½
16 or 17	201 or 227	8 x 30	240	28	615	10	77½	35	72½
18	254	8½ x 32	272	31	754	10	83½	38	77½
19 or 20	283 or 314	9 x 35	315	33	855	10	89½	41	82½
21	346	9 x 40	360	36	1,017	10	93½	46	85½
22	380	10 x 41	410	39	1,194	10	97½	47	89
23 or 24	415 or 452	10½ x 43	451	41	1,320	11	101½	49	93
25	491	11 x 45	495	44	1,520	11	105½	51	97
26	531	11 x 48	528	46	1,662	12	109½	54	99½
27	572	11 x 51	561	49	1,885	12	113½	57	103½
28	621	11½ x 54	621	52	2,123	12	117½	60	109½
29	660	12 x 57	684	55	2,375	12	121½	63	111½
30	707	12 x 60	720	58	2,642	12	125½	66	115½
31 or 32	754 or 804	12½ x 63	807	61	2,922	13	129½	69	118½
33	855	13 x 66	858	64	3,217	13	133½	72	122½
34	908	13½ x 69	932	67	3,525	13	137½	75	126½
35	962	14 x 72	1,008	70	3,848	14	141½	78	129½
36 or 37	1,017 or 1,075	14½ x 75	1,087	73	4,185	14	145½	81	133½
38	1,134	15 x 78	1,170	76	4,536	14	149½	84	137½
39 or 40	1,194 or 1,256	15½ x 81	1,255	79	4,901	14	153½	87	141½
41	1,320	16 x 84	1,344	82	5,281	14	157½	90	145½

SPECIFICATIONS FOR EXHAUST SYSTEMS
(Continued)

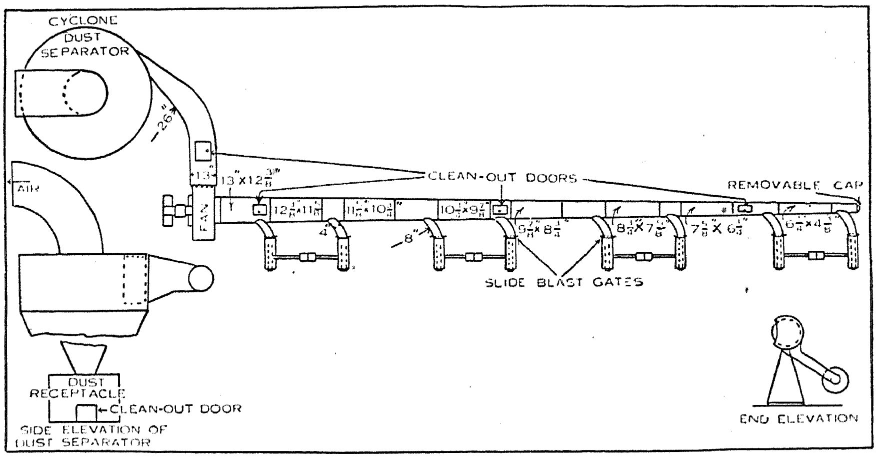
Dimensions of Branch Pipes

The following table gives the diameter in inches of the main suction duct at any point for any number of uniform size branch pipes when the area of the main at any point is made equal to the combined areas of the branch pipes preceding that point plus 20 per cent, the minimum required by the specifications:

Number of branch pipes.	Diameter of Branch Pipes in Inches. 3	3½	4	4½	5	5½	6	6½	7
	Area of Each Branch Pipe in Square Inches.								
	7.07	9.62	12.566	15.9	19.635	23.758	28.274	33.183	38.485
	Area of Each Branch Pipe Plus 20 Per cent (Square Inches).								
	8.484	11.544	15.08	19.08	23.562	28.51	33.93	39.82	46.182
1	3⅜	3⅞	4⅜	5	5½	6	6⅝	7⅛	7¾
2	4¾	5½	6¼	7	7¾	8⅝	9¼	10⅛	10⅞
3	5¾	6⅝	7⅝	8⅝	9½	10½	11½	12⅜	13¼
4	6⅝	7¾	8¾	9⅞	11	12⅛	13⅛	14¼	15⅜
5	7⅜	8⅝	9⅞	11	12¼	13½	14¾	16	17⅛
6	8⅛	9½	10¾	12⅛	13½	14¾	16⅛	17½	18¾
7	8¾	10¼	11⅝	13⅛	14½	16	17½	18⅞	20¼
8	9⅜	10⅞	12⅜	14	15½	17⅛	18⅝	20⅛	21¾
9	9⅞	11½	13⅛	14⅞	16½	18⅛	19¾	21⅜	23
10	10½	12⅛	13⅞	15⅝	17⅜	19⅛	20¾	22½	24¼
11	11	12¾	14⅝	16⅜	18¼	20	21⅞	23⅝	25½
12	11½	13⅜	15¼	17⅛	19	20⅞	22¾	24¾	26⅝
13	11⅞	13⅞	15⅞	17⅞	19¾	21¾	23¾	25¾	27¾
14	12⅜	14⅜	16½	18½	20½	22⅝	24⅝	26¾	28¾
15	12¾	14⅞	17	19⅛	21¼	23⅜	25½	27⅝	29¾
16	13¼	15⅜	17⅝	19¾	22	24⅛	26⅜	28½	30¾
17	13⅝	15⅞	18⅛	20⅜	22⅝	24⅞	27⅛	29⅜	31⅝
18	14	16⅜	18⅝	21	23¼	25⅝	27⅞	30¼	32⅝
19	14⅜	16¾	19⅛	21½	23⅞	26¼	28¾	31⅛	33½
20	14¾	17⅛	19⅝	22⅛	24½	27	29½	31⅞	34⅜
21	15⅛	17⅝	20⅛	22⅝	25⅛	27⅝	30⅛	32¾	35⅛
22	15½	18	20⅝	23⅛	25¾	28⅜	30⅞	33½	36
23	15¾	18½	21⅛	23¾	26¾	29	31½	34¼	36¾
24	16⅛	18⅞	21½	24¼	26⅞	29⅝	32¼	34⅞	37⅝
25	16½	19¼	22	24¾	27½	30⅛	32⅞	35⅝	38⅜
26	16¾	19⅝	22⅜	25⅛	28	30¾	33½	36⅜	39⅛
27	17⅛	20	22⅞	25⅝	28½	31⅜	34⅛	37	39⅞
28	17½	20⅜	23¼	26⅛	29	32	34¾	37¾	40⅝
29	17¾	20¾	23⅝	26⅝	29½	32½	35½	38⅜	41⅜
30	18	21	24	27	30	33	36	39	42

SPECIFICATIONS FOR EXHAUST SYSTEMS
(*Concluded*)

The accompanying illustration shows an exhaust system for eight 14-inch emery wheels, designed in conformity with these specifications. For eight 14-inch buffing wheels, the branch pipes would have to be not less than 4½ inches in diameter and the increased size of the main suction duct and the fan would have to be determined as provided by the specifications. The main discharge



PLAN AND ELEVATIONS OF EXHAUST SYSTEM FOR EIGHT 14-INCH EMERY WHEELS

pipe also would have to be larger and the cyclone separator should be considerably larger for buffing wheels than for emery wheels. The dimensions on the tapered sections indicate diameters at large and small ends, respectively. The area of the main suction duct at the small end of each tapered section equals the sum of the areas of the preceding branch pipes, plus 20 per cent.

SECTION VI

MISCELLANEOUS TABLES

GROSS TON CONVERSION TABLES

Pig iron and scrap, two of the most essential foundry raw materials are bought and sold upon a basis of gross ton weight. Previous to the war, many grades of the latter were computed upon a net or 2000-pound ton unit, but through the influence of the government during and since the period of federal control, the gross ton has come to be the accepted standard for all classes of the commodities mentioned. The following tables give the equivalent weight in pounds from 1 to 340 gross tons. The decimal parts of a gross ton are presented in tabular form on pages 278 and 279.

TABLE SHOWING VALUES OF GROSS TONS IN POUNDS

Tons	Pounds	Tons	Pounds	Tons	Pounds	Tons	Pounds
1	2,240	36	80,640	71	159,040	106	237,440
2	4,480	37	82,880	72	161,280	107	239,680
3	6,720	38	85,120	73	163,520	108	241,920
4	8,960	39	87,360	74	165,760	109	244,160
5	11,200	40	89,600	75	168,000	110	246,400
6	13,440	41	91,840	76	170,240	111	248,640
7	15,680	42	94,080	77	172,480	112	250,880
8	17,920	43	96,320	78	174,720	113	253,120
9	20,160	44	98,560	79	176,960	114	255,360
10	22,400	45	100,800	80	179,200	115	257,600
11	24,640	46	103,040	81	181,440	116	259,840
12	26,880	47	105,280	82	183,680	117	262,080
13	29,120	48	107,520	83	185,920	118	264,320
14	31,360	49	109,760	84	188,160	119	266,560
15	33,600	50	112,000	85	190,400	120	268,800
16	35,840	51	114,240	86	192,640	121	271,040
17	38,080	52	116,480	87	194,880	122	273,280
18	40,320	53	118,720	88	197,120	123	275,520
19	42,560	54	120,960	89	199,360	124	277,760
20	44,800	55	123,200	90	201,600	125	280,000
21	47,040	56	125,440	91	203,840	126	282,240
22	49,280	57	127,680	92	206,080	127	284,480
23	51,520	58	129,920	93	208,320	128	286,720
24	53,760	59	132,160	94	210,560	129	288,960
25	56,000	60	134,400	95	212,800	130	291,200
26	58,240	61	136,640	96	215,040	131	293,440
27	60,480	62	138,880	97	217,280	132	295,680
28	62,720	63	141,120	98	219,520	133	297,920
29	64,960	64	143,360	99	221,760	134	300,160
30	67,200	65	145,600	100	224,000	135	302,400
31	69,440	66	147,840	101	226,240	136	304,640
32	71,680	67	150,080	102	228,480	137	306,880
33	73,920	68	152,320	103	230,720	138	309,120
34	76,160	69	154,560	104	232,960	139	311,360
35	78,400	70	156,800	105	235,200	140	313,600

GROSS TON CONVERSION TABLES
(*Concluded*)

Tons	Pounds	Tons	Pounds	Tons	Pounds	Tons	Pounds
141	315,840	191	427,840	241	539,840	291	651,840
142	318,080	192	430,080	242	542,080	292	654,080
143	320,320	193	432,320	243	544,320	293	656,320
144	322,560	194	434,560	244	546,560	294	658,560
145	324,800	195	436,800	245	548,800	295	660,800
146	327,040	196	439,040	246	551,040	296	663,040
147	329,280	197	441,280	247	553,280	297	665,280
148	331,520	198	443,520	248	555,520	298	667,520
149	333,760	199	445,760	249	557,760	299	669,760
150	336,000	200	448,000	250	560,000	300	672,000
151	338,240	201	450,240	251	562,240	301	674,240
152	340,480	202	452,480	252	564,480	302	676,480
153	342,720	203	454,720	253	566,720	303	678,720
154	344,960	204	456,960	254	568,960	304	680,960
155	347,200	205	459,200	255	571,200	305	683,200
156	349,440	206	461,440	256	473,440	306	685,440
157	351,680	207	463,680	257	575,680	307	687,680
158	353,920	208	465,920	258	577,920	308	689,920
159	356,160	209	468,160	259	580,160	309	693,160
160	358,400	210	470,400	260	582,400	310	694,400
161	360,640	211	472,640	261	584,640	311	696,640
162	362,880	212	474,880	262	586,880	312	698,880
163	365,120	213	477,120	263	589,120	313	701,120
164	367,360	214	479,360	264	591,360	314	703,360
165	369,600	215	481,600	265	593,600	315	705,600
166	371,840	216	483,840	266	595,840	316	707,840
167	374,080	217	486,080	267	598,080	317	710,080
168	376,320	218	488,320	268	600,320	318	712,320
169	378,560	219	490,560	269	602,560	319	714,560
170	380,800	220	492,800	270	604,800	320	716,800
171	383,040	221	495,040	271	607,040	321	719,040
172	385,280	222	497,280	272	609,280	322	721,280
173	387,520	223	499,520	273	611,520	323	723.520
174	389,760	224	501,760	274	613,760	324	725,760
175	392.000	225	504,000	275	616,000	325	728,000
176	394,240	226	506,240	276	618,240	326	730,240
177	396,480	227	508,480	277	620,480	327	732,480
178	398,720	228	510,720	278	622,720	328	734,720
179	400,960	229	512,960	279	624,960	329	736,960
180	403,200	230	515,200	280	627,200	330	739,200
181	405,440	231	517,440	281	629,440	331	741,440
182	407,680	232	519,680	282	631,680	332	743,680
183	409,920	233	521,920	283	633,920	333	745,920
184	412,160	234	524,160	284	636,160	334	748,160
185	414,400	235	526,400	285	638,400	335	750,400
186	416,640	236	528,640	286	640,640	336	752,640
187	418,880	237	530,880	287	642,880	337	754,880
188	421,120	238	533,120	288	645,120	338	757,120
189	423,360	239	535,360	289	647,360	339	759,360
190	425,600	240	537,600	290	649,600	340	761,600

DECIMAL PARTS OF A GROSS TON

To reduce railroad weights in pounds to tons and decimal fractions this table saves much computation. Assuming a carload of pig iron, scrap or coke weighs 90,680 pounds, the table on page 276 shows that 40 tons is 89,600 pounds, leaving a remainder of 1080 pounds, which the following table indicates is .4821 of a ton. The total carload therefore is 40.4821 tons. Multiplication by the cost per ton gives the exact cost of the carload and multiplication by the freight rate gives the exact charges.

Pounds	Decimal	Pounds	Decimal	Pounds	Decimal	Pounds	Decimal
1	0004	160	0714	410	1830	660	2946
2	0009	170	0759	420	1875	670	2991
3	0013	180	0804	430	1920	680	3036
4	0018	190	0848	440	1964	690	3080
5	0022	200	0893	450	2009	700	3125
6	0027	210	0938	460	2054	710	3170
7	0031	220	0982	470	2098	720	3214
8	0036	230	1027	480	2143	730	3259
9	0040	240	1071	490	2188	740	3304
10	0045	250	1116	500	2232	750	3348
15	0067	260	1161	510	2277	760	3393
20	0089	270	1205	520	2321	770	3438
30	0134	280	1250	530	2366	780	3482
40	0179	290	1295	540	2411	790	3527
50	0223	300	1339	550	2455	800	3571
60	0268	310	1384	560	2500	810	3616
70	0313	320	1429	570	2545	820	3661
80	0357	330	1473	580	2589	830	3705
90	0402	340	1518	590	2634	840	3750
100	0446	350	1563	600	2679	850	3795
110	0491	360	1607	610	2723	860	3839
120	0536	370	1652	620	2768	870	3884
130	0580	380	1696	630	2813	880	3929
140	0625	390	1741	640	2857	890	3973
150	0670	400	1786	650	2902	900	4018

DECIMAL PARTS OF A GROSS TON
(Concluded)

Pounds	Decimal	Pounds	Decimal	Pounds	Decimal	Pounds	Decimal
910	4063	1260	5625	1610	7188	1960	8750
920	4107	1270	5670	1620	7232	1970	8795
930	4152	1280	5714	1630	7277	1980	8839
940	4196	1290	5759	1640	7321	1990	8884
950	4241	1300	5804	1650	7366	2000	8929
960	4286	1310	5848	1660	7411	2010	8973
970	4330	1320	5893	1670	7455	2020	9018
980	4375	1330	5938	1680	7500	2030	9063
990	4420	1340	5982	1690	7545	2040	9107
1000	4464	1350	6027	1700	7589	2050	9152
1010	4509	1360	6071	1710	7634	2060	9196
1020	4554	1370	6116	1720	7679	2070	9241
1030	4598	1380	6161	1730	7723	2080	9286
1040	4643	1390	6205	1740	7768	2090	9330
1050	4688	1400	6250	1750	7813	2100	9675
1060	4732	1410	6295	1760	7857	2110	9420
1070	4777	1420	6339	1770	7902	2120	9464
1080	4821	1430	6384	1780	7946	2130	9509
1090	4866	1440	6429	1790	7991	2140	9554
1100	4911	1450	6473	1800	8036	2150	9598
1110	4955	1460	6518	1810	8080	2160	9643
1120	5000	1470	6553	1820	8125	2170	9688
1130	5045	1480	6607	1830	8170	2175	9710
1140	5089	1490	6652	1840	8214	2180	9732
1150	5134	1500	6696	1850	8259	2185	9754
1160	5179	1510	6741	1860	8304	2190	9777
1170	5223	1520	6786	1870	8348	2195	9799
1180	5268	1530	6830	1880	8393	2200	9821
1190	5313	1540	6875	1890	8438	2205	9844
1200	5357	1550	6930	1900	8482	2210	9866
1210	5402	1560	6964	1910	8527	2215	9888
1220	5446	1570	7009	1920	8571	2220	9911
1230	5491	1580	7054	1930	8616	2225	9933
1240	5536	1590	7098	1940	8661	2230	9955
1250	5580	1600	7143	1950	8705	2235	9978

NET AND GROSS TON EQUIVALENTS

The following table is in common use by dealers in scrap iron and steel to convert the price of tonnage material from net to gross ton or vice versa. Its use is simple. Assuming a quotation is made on the basis of $38 per net ton, and it is desired to know the cost per gross ton. The $38 is found in the middle column and in the column to the left is found $42.56, which is the equivalent cost for a gross ton. Assuming that the $38 quotation was on a gross ton, and it is desired to know the equivalent for a net ton. The figure to the right reading $33.93 is the equivalent for the net ton.

The table may be used also to convert tonnages. Thus 100 gross tons is equal to 112 net tons, and 100 net tons is equal to 89 gross tons. This is found by reversing the manner of reading the figures for prices

This table serves for quotations up to $50.75 per ton and for quantities up to 5075 tons.

TABLE OF NET AND GROSS TON EQUIVALENTS

Gross		Net	Gross		Net	Gross		Net
$ 1.12	**$ 1.00**	$ .89	6.72	**6.00**	5.36	12.60	**11.25**	10.04
1.40	**1.25**	1.12	7.00	**6.25**	5.58	12.88	**11.50**	10.27
1.68	**1.50**	1.34	7.28	**6.50**	5.80	13.16	**11.75**	10.49
1.96	**1.75**	1.56	7.56	**6.75**	6.03	13.44	**12.00**	10.71
2.24	**2.00**	1.79	7 84	**7.00**	6.25	13.72	**12.25**	10.94
2.52	**2.25**	2.01	8.12	**7.25**	6.47	14.00	**12.50**	11.16
2.80	**2.50**	2.23	8.40	**7.50**	6.70	14.28	**12.75**	11.38
3.08	**2.75**	2.46	8.68	**7.75**	6 92	14.56	**13.00**	11.61
3.36	**3.00**	2.68	8.96	**8.00**	7.14	14.84	**13.25**	11.83
3.64	**3.25**	2.90	9.24	**8.25**	7.37	15.12	**13.50**	12.05
3.92	**3.50**	3.13	9.52	**8.50**	7.59	15.40	**13.75**	12.28
4.20	**3.75**	3.35	9.80	**8.75**	7.81	15.68	**14.00**	12.50
4.48	**4.00**	3.57	10.08	**9.00**	8.04	15.96	**14.25**	12.72
4.76	**4.25**	3.79	10.36	**9.25**	8.26	16.24	**14.50**	12.95
5.04	**4.50**	4.02	10.64	**9 50**	8.48	16.52	**14.75**	13.17
5.32	**4.75**	4.24	10.92	**9.75**	8 71	16.80	**15.00**	13.39
5.60	**5.00**	4.46	11.20	**10.00**	8.93	17.08	**15.25**	13.62
5.88	**5.25**	4.69	11.48	**10.25**	9.15	17.36	**15.50**	13.84
6.16	**5.50**	4.91	11.76	**10.50**	9.38	17.64	**15.75**	14.06
6.44	**5.75**	5.13	12.04	**10.75**	9 60	17.92	**16.00**	14.29
			12.32	**11.00**	9.82	18.20	**16.25**	14.51

NET AND GROSS TON EQUIVALENTS
(Concluded)

Gross		Net	Gross		Net	Gross		Net
18.48	**16.50**	14.73	31.36	**28.00**	25.00	44.24	**39.50**	35.27
18.76	**16.75**	14.96	31.64	**28.25**	25.22	44.52	**39.75**	35.49
19.04	**17.00**	15.18	31.92	**28.50**	25.45	44.80	**40.00**	35.71
19.32	**17.25**	15.40	32.20	**28.75**	25.67	45.08	**40.25**	35.94
19.60	**17.50**	15.63	32.48	**29.00**	25.89	45.36	**40.50**	36.16
19.88	**17.75**	15.85	32.76	**29.25**	26.12	45.64	**40.75**	36.38
20.16	**18.00**	16.07	33.04	**29.50**	26.34	45.92	**41.00**	36.61
20.44	**18.25**	16.29	33.32	**29.75**	26.56	46.20	**41.25**	36.83
20.72	**18.50**	16.52	33.60	**30.00**	26.79	46.48	**41.50**	37.05
21.00	**18.75**	16.74	33.88	**30.25**	27.01	46.76	**41.75**	37.28
21.28	**19.00**	16.96	34.16	**30.50**	27.23	47.04	**42.00**	37.50
21.56	**19.25**	17.19	34.44	**30.75**	27.46	47.32	**42.25**	37.72
21.84	**19.50**	17.41	34.72	**31.00**	27.68	47.60	**42.50**	37.95
22.12	**19.75**	17.63	35.00	**31.25**	27.90	47.88	**42.75**	38.17
22.40	**20.00**	17.86	35.28	**31.50**	28.13	48.16	**43.00**	38.39
22.68	**20.25**	18.08	35.56	**31.75**	28.35	48.44	**43.25**	38.62
22.96	**20.50**	18.30	35.84	**32.00**	28.57	48.72	**43.50**	38.84
23.24	**20.75**	18.53	36.12	**32.25**	28.79	49.00	**43.75**	39.06
23.52	**21.00**	18.75	36.40	**32.50**	29.02	49.28	**44.00**	39.29
23.80	**21.25**	18.97	36.68	**32.75**	29.24	49.56	**44.25**	39.51
24.08	**21.50**	19.20	36.96	**33.00**	29.46	49.84	**44.50**	39.73
24.36	**21.75**	19.42	37.24	**33.25**	29.69	50.12	**44.75**	39.96
24.64	**22.00**	19.64	37.52	**33.50**	29.91	50.40	**45.00**	40.18
24.92	**22.25**	19.87	37.80	**33.75**	30.13	50.68	**45.25**	40.40
25.20	**22.50**	20.09	38.08	**34.00**	30.36	50.96	**45.50**	40.63
25.48	**22.75**	20.31	38.36	**34.25**	30.58	51.24	**45.75**	40.85
25.76	**23.00**	20.54	38.64	**34.50**	30.80	51.52	**46.00**	41.07
26.04	**23.25**	20.76	38.92	**34.75**	31.03	51.80	**46.25**	41.29
26.32	**23.50**	20.98	39.20	**35.00**	31.25	52.08	**46.50**	41.52
26.60	**23.75**	21.21	39.48	**35.25**	31.47	52.36	**46.75**	41.74
26.88	**24.00**	21.43	39.76	**35.50**	31.70	52.04	**47.00**	41.96
27.16	**24.25**	21.65	40.04	**35.75**	31.92	52.92	**47.25**	42.19
27.44	**24.50**	21.88	40.32	**36.00**	32.14	53.20	**47.50**	42.41
27.72	**24.75**	22.10	40.60	**36.25**	32.37	53.48	**47.75**	42.63
28.00	**25.00**	22.32	40.88	**36.50**	32.59	53.76	**48.00**	42.86
28.28	**25.25**	22.54	41.16	**36.75**	32.81	54.04	**48.25**	43.08
28.56	**25.50**	22.77	41.44	**37.00**	33.04	54.32	**48.50**	43.30
28.84	**25.75**	22.99	41.72	**37.25**	33.26	54.60	**48.75**	43.53
29.12	**26.00**	23.21	42.00	**37.50**	33.48	54.88	**49.00**	43.75
29.40	**26.25**	23.44	42.28	**37.75**	33.71	55.16	**49.25**	43.97
29.68	**26.50**	23.66	42.56	**38.00**	33.93	55.44	**49.50**	44.20
29.96	**26.75**	23.88	42.84	**38.25**	34.15	55.72	**49.75**	44.42
30.24	**27.00**	24.11	43.12	**38.50**	34.38	56.00	**50.00**	44.64
30.52	**27.25**	24.33	43.40	**38.75**	34.60	56.28	**50.25**	44.87
30.80	**27.50**	24.55	43.68	**39.00**	34.82	56.56	**50.50**	45.09
31.08	**27.75**	24.78	43.96	**39.25**	35.04	56.84	**50.75**	45.31

WEIGHT OF SQUARE FOOT OF VARIOUS METALS

Thickness of Section (Inches)	Gray Iron (Lbs.)	Wrought Iron (Lbs.)	Brass (Lbs.)	Copper (Lbs.)	Tin (Lbs.)	Steel (Lbs.)	Lead (Lbs.)
1/16	2.34	2.52	2.7	2.88	2.35	2.59	3.69
1/8	4.68	5.04	5.4	5.76	4.71	5.18	7.38
3/16	7.02	7.56	8.1	8.64	7.07	7.77	11.07
1/4	9.36	10.08	10.8	11.52	9.43	10.36	14.76
5/16	11.70	12.60	13.5	14.40	11.79	12.96	18.45
3/8	14.04	15.12	16.2	17.28	14.14	15.55	22.14
7/16	16.38	17.64	18.9	20.16	16.50	18.14	25.83
1/2	18.72	20.16	21.6	23.04	18.86	20.73	29.52
9/16	21.06	22.68	24.3	25.93	21.22	23.32	33.21
5/8	23.40	25.20	27.0	28.80	23.58	25.92	36.90
11/16	25.74	27.72	29.7	31.68	25.93	28.51	40.59
3/4	28.08	30.24	32.4	34.56	28.29	31.10	44.28
13/16	30.42	32.76	35.1	37.44	30.65	33.69	47.97
7/8	32.76	35.28	37.8	40.32	33.01	36.28	51.66
15/16	35.10	34.80	40.5	43.20	35.37	38.88	55.35
1	37.44	40.32	43.2	46.08	37.72	41.47	59.04
1 1/16	39.78	42.84	45.9	48.96	40.80	44.06	62.73
1 1/8	42.12	45.36	48.6	51.84	42.44	46.65	66.42
1 3/16	44.46	47.88	51.3	54.52	44.80	49.24	70.11
1 1/4	46.80	50.40	54.0	57.60	47.16	51.84	73.80
1 5/16	49.14	52.92	56.7	60.48	49.51	54.43	77.49
1 3/8	51.48	55.44	59.4	63.36	51.87	57.02	81.18
1 7/16	53.82	57.06	62.1	66.24	54.23	59.61	84.87
1 1/2	56.16	60.48	64.8	69.12	56.59	62.20	88.56
1 9/16	58.50	63.00	67.5	72.00	58.95	64.80	92.25
1 5/8	60.84	65.52	70.2	74.88	61.30	67.39	95.94
1 11/16	63.18	68.04	72.9	77.76	63.66	69.98	99.63
1 3/4	65.52	70.56	75.6	80.64	66.02	72.57	103.32
1 13/16	67.86	73.08	78.3	83.52	68.38	75.16	107.01
1 7/8	70.20	75.60	81.0	86.40	70.74	77.76	110.40
1 15/16	72.54	78.12	83.7	89.28	73.09	80.35	114.39
2	74.88	80.64	86.4	92.16	75.45	82.94	118.08
2 1/4	84.24	90.72	97.2	103.68	84.88	93.31	132.84
2 1/2	93.60	100.80	108.0	115.20	94.32	103.68	147.60
3	112.32	120.96	129.6	138.24	113.18	124.41	177.12

DECIMAL EQUIVALENTS OF FRACTIONS

DECIMAL EQUIVALENTS FOR 64ths

1/64	.01563	17/64	.26563	33/64	.51563	49/64	.76563
1/32	.03125	9/32	.28125	17/32	.53125	25/32	.78125
3/64	.04688	19/64	.29688	35/64	.54688	51/64	.79688
1/16	.0625	5/16	.3125	9/16	.5625	13/16	.8125
5/64	.07813	21/64	.32813	37/64	.57813	53/64	.82813
3/32	.09375	11/32	.34375	19/32	.59375	27/32	.84375
7/64	.10938	23/64	.35938	39/64	.60938	55/64	.85938
1/8	.125	3/8	.375	5/8	.625	7/8	.875
9/64	.14063	25/64	.39063	41/64	.64063	57/64	.89063
5/32	.15625	13/32	.40625	21/32	.65625	29/32	.90625
11/64	.17188	27/64	.42188	43/64	.67188	59/64	.92188
3/16	.1875	7/16	.4375	11/16	.6875	15/16	.9375
13/64	.20313	29/64	.45313	45/64	.70313	61/64	.95313
7/32	.21875	15/32	.46875	23/32	.71875	31/32	.96875
15/64	.23438	31/64	.48438	47/64	.73438	63/64	.98438
1/4	.25	1/2	.5	3/4	.75	1	1.00000

DECIMAL EQUIVALENTS OF FRACTIONS
(Concluded)

EQUIVALENTS TO 3rds, 6ths, 12ths AND 24ths IN 64ths

1/24	.04167	3/64	9/24	.375	3/8	17/24	.70833	45/64
1/12	.08333	5/64	5/12	.41667	27/64	9/12	.75	3/4
3/24	.125	1/8	11/24	.45833	29/64	19/24	.79167	51/64
1/6	.16667	11/64	3/6	.5	1/2	5/6	.83333	53/64
5/24	.20833	13/64	13/24	.54167	35/64	21/24	.875	7/8
3/12	.25	1/4	7/12	.58333	37/64	11/12	.91667	59/64
7/24	.29167	19/64	15/24	.625	5/8	23/24	.95833	61/64
1/3	.33333	21/64	2/3	.66667	43/64	.....	.....	..

EQUIVALENTS TO 7ths, 14ths AND 28ths IN 64ths

1/28	.03571	1/32	5/14	.35714	23/64	19/28	.67857	43/64
1/14	.07143	5/64	11/28	.39286	25/64	5/7	.71429	23/32
3/28	.10714	7/64	3/7	.42857	27/64	21/28	.75	3/4
1/7	.14286	9/64	13/28	.46429	15/32	11/14	.78571	25/32
5/28	.17857	11/64	7/14	.5	1/2	23/28	.82143	53/64
3/14	.21429	7/32	15/28	.53571	17/32	6/7	.85714	55/64
7/28	.25	1/4	4/7	.57143	37/64	25/28	.89286	57/64
2/7	.28571	9/32	17/28	.60714	39/64	13/14	.92857	59/64
9/28	.32143	21/64	9/14	.64287	41/64	27/28	.96429	31/32

TABLE FOR CHANGING CENTIGRADE TO FAHRENHEIT

Rule to change the values: $\text{Fahr.} = \frac{9}{5} C + 32°.$

$$\text{Cent.} = (F - 32°)\frac{5}{9}$$

Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.
—10	+14	22	71.6	54	129.2	86	186.8	190	374
— 9	+15.8	23	73.4	55	131	87	188.6	195	383
— 8	+17.6	24	75.2	56	132.8	88	190.4	200	392
— 7	+19.4	25	77	57	134.6	89	192.2	205	401
— 6	+21.2	26	78.8	58	136.4	90	194	210	410
— 5	+23	27	80.6	59	138.2	91	195.8	215	419
— 4	+24.8	28	82.4	60	140	92	197.6	220	428
— 3	+26.6	29	84.2	61	141.8	93	199.4	225	437
— 2	+28.4	30	86	62	143.6	94	201.2	230	446
— 1	+30.2	31	87.8	63	145.4	95	203	235	455
0	+32	32	89.6	64	147.2	96	204.8	240	464
+ 1	33.8	33	91.4	65	149	97	206.6	245	473
2	35.6	34	93.2	66	150.8	98	208.4	250	482
3	37.4	35	95	67	152.6	99	210.2	255	491
4	39.2	36	96.8	68	154.4	100	212	260	500
5	41	37	98.6	69	156.2	105	221	265	509
6	42.8	38	100.4	70	158	110	230	270	518
7	44.6	39	102.2	71	159.8	115	239	275	527
8	46.4	40	104	72	161.6	120	248	280	536
9	48.2	41	105.8	73	163.4	125	257	285	545
10	50	42	107.6	74	165.2	130	266	290	554
11	51.8	43	109.4	75	167	135	275	295	563
12	53.6	44	111.2	76	168.8	140	284	300	572
13	55.4	45	113	77	170.6	145	293	305	581
14	57.2	46	114.8	78	172.4	150	302	310	590
15	59	47	116.6	79	174.2	155	311	315	599
16	60.8	48	118.4	80	176	160	320	320	608
17	62.6	49	120.2	81	177.8	165	329	325	617
18	64.4	50	122	82	179.6	170	338	330	626
19	66.2	51	123.8	83	181.4	175	347	335	635
20	68	52	125.6	84	183.2	180	356	340	644
21	69.8	53	127.4	85	185	185	365	345	653

TABLE FOR CHANGING CENTIGRADE TO FAHRENHEIT
(Concluded)

Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.	Degrees, Cent.	Degrees, Fahr.
350	662	510	950	670	1238	830	1526	990	1814
355	671	515	959	675	1247	835	1535	995	1823
360	680	520	968	680	1256	840	1544	1000	1832
365	689	525	977	685	1265	845	1553	1005	1841
370	698	530	986	690	1274	850	1562	1010	1850
375	707	535	995	695	1283	855	1571	1015	1859
380	716	540	1004	700	1292	860	1580	1020	1868
385	725	545	1013	705	1301	865	1589	1025	1877
390	734	550	1022	710	1310	870	1598	1030	1886
395	743	555	1031	715	1319	875	1607	1035	1895
400	752	560	1040	720	1328	880	1616	1040	1904
405	761	565	1049	725	1337	885	1625	1045	1913
410	770	570	1058	730	1346	890	1634	1050	1922
415	779	575	1067	735	1355	895	1643	1055	1931
420	788	580	1076	740	1364	900	1652	1060	1940
425	797	585	1085	745	1373	905	1661	1065	1949
430	806	590	1094	750	1382	910	1670	1070	1958
435	815	595	1103	755	1391	915	1679	1075	1967
440	824	600	1112	760	1400	920	1688	1080	1976
445	833	605	1121	765	1409	925	1697	1085	1985
450	842	610	1130	770	1418	930	1706	1090	1994
455	851	615	1139	775	1427	935	1715	1095	2003
460	860	620	1148	780	1436	940	1724	1100	2012
465	869	625	1157	785	1445	945	1733	1105	2021
470	878	630	1166	790	1454	950	1742	1110	2030
475	887	635	1175	795	1463	955	1751	1115	2039
480	896	640	1184	800	1472	960	1760	1120	2048
485	905	645	1193	805	1481	965	1769	1125	2057
490	914	650	1202	810	1490	970	1778	1130	2066
495	923	655	1211	815	1499	975	1787	1135	2075
500	932	660	1220	820	1508	980	1796	1140	2084
505	941	665	1229	825	1517	985	1805	1145	2093

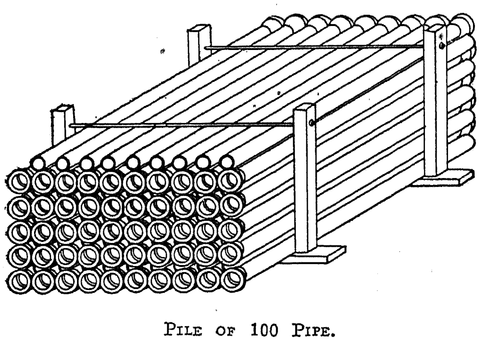
VOLUME AND WEIGHT OF PILED, BELL-AND-SPIGOT, CAST-IRON PIPE

Size of pipe, inches.	Head in feet.	Thickness of metal, inches.	Weight of one pipe, in pounds.	No. of pipe in one ton of 2,240 pounds.	Cubic feet in one ton of 2,240 pounds.	No. of pipe in 40 cubic feet.	Pounds of pipe in 40 cubic feet.	Cubic ft. in one pipe.
3	100	0.38	167	13.41	21.414	24.935	4,164.121	1.604
3	200	0.42	185	12.11	19.796	24.465	4,523.320	1.635
3	300	0.45	200	11.20	18.961	23.626	4,724.224	1.693
3	400	0.45	200	11.20	18.961	23.626	4,724.224	1.693
4	100	0.40	230	9.74	23.646	16.479	3,787.720	2.428
4	200	0.42	243	9.26	22.953	16.135	3,920.034	2.479
4	300	0.45	260	8.61	22.873	15.754	4,004.480	2.539
4	400	0.47	265	8.45	21.823	15.491	4,104.372	2.582
5	100	0.42	295	7.59	26.537	11.433	3,376.136	3.495
5	200	0.45	315	7.11	25.356	11.222	3,534 332	3.565
5	300	0.48	338	6.63	24.135	10.983	3,712.000	3.642
5	400	0.51	355	6.31	23.503	10.738	3,811.172	3.725
6	100	0.43	364	6.15	28.825	8.539	3,008.000	4.684
6	200	0.47	393	5.70	27.285	8.356	3,283 240	4.787
6	300	0.51	426	5.25	25.764	8.177	3,477.224	4.900
6	400	0.54	445	5.03	25.114	8.017	3,567.092	4,990
8	100	0.47	513	4.36	33.425	5.224	2,680.164	7.656
8	200	0.51	567	3.95	30.833	5.118	2,906.196	7.804
8	300	0.56	624	3.59	28.666	5.009	3,129.392	7 985
8	400	0.61	665	3.37	27.456	4.906	3,262.730	8.152
10	100	0.50	685	3.27	37.400	3.454	2,366.256	11.579
10	200	0.56	765	2.93	34.676	3.388	2,587.484	11.826
10	300	0.62	852	2.63	31.800	3.317	2,826.248	12.058
10	400	0.68	920	2.43	30.266	3.216	2,959.172	12.435
12	100	0.53	870	2.57	41.230	2.497	2,172.492	16.018
12	200	0.60	985	2.27	37.218	2.444	2,407.236	16 367
12	300	0.68	1,110	2.02	35.858	2.384	2,646.288	16.778
12	400	0.75	1,210	1.98	34.839	2.159	2,612.892	17.549
14	100	0.56	1,074	2.08	44.310	1.882	2,021.388	21.252
14	200	0.65	1,229	1.82	39.798	1.831	2,250.592	21.843
14	300	0.73	1,399	1.60	35.699	1.794	2,509.568	22.298
14	400	0.82	1,540	1.45	33.242	1.757	2,969.184	22.847
16	100	0.60	1,293	1.73	47.325	1.464	1,893.864	27.308
16	200	0.69	1,496	1.50	41.829	1.434	2,145.788	27.886
16	300	0.79	1,723	1.30	37.095	1.401	2,415.256	28.535
16	400	0.89	1,900	1.18	36.020	1.316	2,490.308	30.578
18	100	0.63	1,532	1.46	48.274	1.211	1,855.876	33.019
18	200	0.74	1,788	1.28	44.456	1.157	2,068.864	34.569
18	300	0.85	2,065	1.08	38.572	1.124	2,321.284	35.583
18	400	0.96	2,300	0.974	35.441	1.100	2,532.076	36.338
20	100	0.66	1,788	1.28	53.874	0.945	1,778.040	41.893
20	200	0.78	2,104	1.06	45.596	0.938	1,963.836	42.854
20	300	0.91	2,444	0.916	39.900	0.918	2,240.272	43.559
20	400	1.03	2,740	0.814	36.508	0.891	2,443.188	44.850

VOLUME AND WEIGHT OF PILED, BELL-AND-SPIGOT CAST-IRON PIPE

(*Concluded*)

Size of pipe, inches.	Head in feet.	Thickness of metal, inches.	Weight of one pipe, in pounds.	No. of pipe in one ton of 2,240 pounds.	Cubic ft. in one ton of 2,240 pounds.	No. of pipe in 40 cubic feet.	Pounds of pipe in 40 cubic feet.	Cubic ft. in one pipe.
24	100	0.75	2,407	0.931	55.122	0.679	1,626.132	59.207
24	200	0.87	2,803	0.799	49.463	0.646	1,811.112	61.906
24	300	1.02	3,299	0.679	43.122	0.630	2,080.876	63.415
24	400	1.16	3,680	0.600	38.783	0.619	2,277.256	64.639
30	100	0.87	3,482	0.649	59.733	0.434	1,513.268	92.039
30	200	1.01	4,027	0.556	52.760	0.421	1,697.492	94.892
30	300	1.19	4,783	0.468	45.550	0.411	1,965.660	97.337
30	400	1.37	5,420	0.413	41.047	0.402	2,181.364	99.387
36	100	0.98	4,699	0.476	63.567	0.299	1,407.388	133.544
36	200	1.14	5,460	0.410	55.586	0.295	1,610.884	135.577
36	300	1.36	6,543	0.342	47.019	0.291	1,903.636	137.484
36	400	1.58	7,490	0.300	42.566	0.282	2,111.516	141.888
40	100	1.09	5,807	0.386	63.591	0.242	1,409.936	164.745
40	200	1.23	6,525	0.343	56.997	0.240	1,570.636	166.174
40	300	1.48	7,858	0.285	48.909	0.233	1,831.588	171.610
40	400	1.72	9,050	0.247	43.413	0.227	2,059.372	175.763
42	100	1.10	6,147	0.364	66.117	0.225	1,353.628	181.640
42	200	1.28	7,100	0.315	58.179	0.216	1,537.664	184.695
42	300	1.54	8,563	0.258	48.802	0.211	1,810.768	189.157
42	400	1.79	9,890	0.248	48.002	0.206	2,043.812	193.559
48	100	1.25	7,982	0.281	65.246	0.171	1,370.164	233.023
48	200	1.41	8,946	0.250	59.800	0.167	1,496.000	239.200
48	300	1.71	10,857	0.206	50.862	0.166	1,758.940	246.903
48	400	1.99	12,550	0.179	44.767	0.163	2,007.856	250.097
60	100	1.40	11,000	0.203	74.817	0.108	1,193.836	368.559
60	200	1.68	13,260	0.169	63.188	0.107	1,418.568	373.897
60	300	2.05	16,040	0.139	52.903	0.105	1,685.760	380.599
60	400	2.41	18,970	0.118	46.253	0.102	1,938.820	391.978



PILE OF 100 PIPE.

WEIGHT OF STEEL IN POUNDS FROM 1 TO 1,000 CUBIC INCHES

Cu. Ins.	Cubic Inches 0	100	200	300	400	500	600	700	800	900
	Pounds									
1	0.286	28.886	57.486	86.086	114.686	143.286	171.886	200.486	229.086	257.686
2	0.572	29.172	57.772	86.372	114.972	143.572	172.172	200.772	229.372	257.972
3	0.858	29.458	58.058	86.658	115.258	143.858	172.458	201.058	229.658	258.258
4	1.144	29.744	58.344	86.944	115.544	144.144	172.744	201.344	229.944	258.544
5	1.430	30.030	58.630	87.230	115.830	144.430	173.030	201.630	230.230	258.830
6	1.716	30.316	58.916	87.516	116.116	144.716	173.316	201.916	230.516	259.116
7	2.002	30.602	59.202	87.802	116.402	145.002	173.602	202.202	230.802	259.402
8	2.288	30.888	59.488	88.088	116.688	145.288	173.888	202.488	231.088	259.688
9	2.574	31.174	59.774	88.374	116.974	145.574	174.174	202.774	231.374	259.974
10	2.860	31.469	60.060	88.660	117.260	145.860	174.460	203.060	231.660	260.260
11	3.146	31.746	60.346	88.946	117.546	146.146	174.746	203.346	231.946	260.546
12	3.432	32.032	60.632	89.232	117.832	146.432	175.032	203.632	232.232	260.832
13	3.718	32.318	60.918	89.518	118.118	146.718	175.318	203.918	232.518	261.118
14	4.004	32.604	61.204	89.804	118.404	147,004	175.604	204.204	232.804	261.404
15	4.290	32.890	61.490	90.090	118.690	147.290	175.890	204.490	233.090	261.690
16	4.576	33.176	61.776	90.376	118.976	147.576	176.176	204.776	233.376	261.976
17	4.862	33.462	62.062	90.662	119.262	147.862	176.462	205.062	233.662	262.262
18	5.148	33.748	62.348	90.948	119.548	148.148	176.748	205.348	233.948	262.548
19	5.434	34.034	62.634	91.234	119.834	148.434	177.034	205.634	234.234	262.834
20	5.720	34.320	62.920	91.520	120.120	148.720	177.320	205.920	234.520	263.120
21	6.006	34.606	63.206	91.806	120.406	149.006	177.606	206.206	234.806	263.406
22	6.292	34.892	63.492	92.092	120.692	149.292	177.892	206.492	235.092	263.692
23	6.578	35.178	63.778	92.378	120.978	149.578	178.178	206.778	235.378	263.978
24	6.864	35.464	64.064	92.664	121.264	149.864	178.464	207.064	235.664	264.264
25	7.150	35.750	64.350	92.950	121.550	150.150	178.750	207.350	235.950	264.550
26	7.436	36.036	64.636	93.236	121.836	150.436	179.036	207.636	236.236	264.836
27	7.722	36.322	64.922	93.522	122.122	150.722	179.322	207.922	236.522	265.122
28	8.008	36.608	65.208	93.808	122.408	151.008	179.608	208.208	236.808	265.408
29	8.294	36.894	65.494	94.094	122.694	151.294	179.894	208.494	237.094	265.694
30	8.580	37.180	65.780	94.380	122.980	151.580	180.180	208.780	237.380	265.980
31	8.866	37.466	66.066	94.666	123.266	151.866	180.466	209.066	237.666	266.266
32	9.152	37.752	66.352	94.952	123.552	152.152	180.752	209.352	237.952	266.552
33	9.438	38.038	66.638	95.238	123.838	152.438	181.038	209.638	238.238	266.838
34	9.724	38.324	66.924	95.524	124.124	152.724	181.324	209.924	238.524	267.124
35	10.010	38.610	67.210	95.810	124.410	153.010	181.610	210.210	238.810	267.410
36	10.296	38.896	67.496	96.096	124.696	153.296	181.896	210.496	239.096	267.696
37	10.582	39.182	67.782	96.382	124.982	153.582	182.182	210.782	239.382	267.982
38	10.868	39.468	68.068	96.668	125.268	153.868	182.468	211.068	239.668	268.268
39	11.154	39.754	68.354	96.954	125.554	154.154	182.754	211.354	239.954	268.554
40	11.440	40.040	68.640	97.240	125.840	154.440	183.040	211.640	240.240	268.840
41	11.726	40.326	68.926	97.526	126.126	154.726	183.326	211.926	240.526	269.126
42	12.012	40.612	69.212	97.812	126.412	155.012	183.612	212.212	240.812	269.412
43	12.298	40.898	69.498	98.098	126.698	155.298	183.898	212.498	241.098	269.698
44	12.584	41.184	69.784	98.384	126.984	155.584	184.184	212.784	241.384	269.984
45	12.870	41.470	70.070	98.670	127.270	155.870	184.470	213.070	241.670	270.270
46	13.156	41.756	70.356	98.956	127.556	156.156	184.756	213.356	241.956	270.556
47	13.442	42.042	70.642	99.242	127.842	156.442	185.042	213.642	242.242	270.842
48	13.728	42.328	70.928	99.528	128.128	156.728	185.328	213.928	242.528	271.128
49	14.014	42.614	71.214	99.814	128.414	157.014	185.614	214.214	242.814	271.414
50	14.300	42.900	71.500	100.100	128.700	157.300	185.900	214.500	243.100	271.700

WEIGHT OF STEEL IN POUNDS FROM 1 TO 1,000 CUBIC INCHES

(Concluded)

Cu. Ins.	0	100	200	300	400	500	600	700	800	900
	Pounds									
51	14.586	43.186	71.786	100.386	128.986	157.586	186.186	214.786	243.386	271.986
52	14.872	43.472	72.072	100.672	129.272	157.872	186.472	215.072	243.672	272.272
53	15.158	43.758	72.358	100.958	129.558	158.158	186.758	215.358	243.958	272.558
54	15.444	44.044	72.644	101.244	129.844	158.444	187.044	215.644	244.244	272.844
55	15.730	44.300	72.930	101.530	130.130	158.730	187.330	215.930	244.530	273.130
56	16.016	44.616	73.216	101.816	130.416	159.016	187.616	216.216	244.816	273.416
57	16.302	44.902	73.502	102.102	130.702	159.302	187.902	216.502	245.102	273.702
58	16.588	45.188	73.788	102.388	130.988	159.588	188.188	216.788	245.388	273.988
59	16.874	45.474	74.074	102.674	131.274	159.874	188.474	217.074	245.674	274.274
60	17.160	45.760	74.360	102.960	131.560	160.160	188.760	217.360	245.960	274.560
61	17.446	46.046	74.646	103.246	131.846	160.446	189.046	217.646	246.246	274.846
62	17.732	46.332	74.932	103.532	132.132	160.732	189.332	217.932	246.532	275.132
63	18.018	46.618	75.218	103.818	132.418	161.018	189.618	218.218	246.818	275.418
64	18.304	46.904	75.504	104.104	132.704	161.304	189.904	218.504	247.104	275.704
65	18.590	47.190	75.790	104.390	132.990	161.590	190.190	218.790	247.390	275.990
66	18.876	47.476	76.076	104.676	133.276	161.876	190.476	219.076	247.676	276.276
67	19.162	47.762	76.362	104.962	133.562	162.162	190.762	219.362	247.962	276.562
68	19.448	48.048	76.648	105.248	133.848	162.448	191.048	219.648	248.248	276.848
69	19.734	48.334	76.934	105.534	134.134	162.734	191.334	219.934	248.534	277.134
70	20.020	48.620	77.220	105.820	134.420	163.020	191.620	220.220	248.820	277.420
71	20.306	48.906	77.506	106.106	134.706	163.306	191.906	220.506	249.106	277.706
72	20.592	49.192	77.792	106.392	134.992	163.592	192.192	220.792	249.392	277.992
73	20.878	49.478	78.078	106.678	135.278	163.878	192.478	221.078	249.678	278.278
74	21.164	49.764	78.364	106.964	135.564	164.164	192.764	221.364	249.964	278.564
75	21.450	50.050	78.650	107.250	135.850	164.450	193.050	221.650	250.250	278.850
76	21.736	50.336	78.936	107.536	136.136	164.736	193.336	221.936	250.536	279.136
77	22.022	50.622	79.222	107.822	136.422	165.022	193.622	222.222	250.822	279.422
78	22.308	50.908	79.508	108.108	136.708	165.308	193.908	222.508	251.108	279.708
79	22.594	51.194	79.794	108.394	136.994	165.594	194.194	222.794	251.394	279.994
80	22.880	51.480	80.080	108.680	137.280	165.880	194.480	223.080	251.680	280.280
81	23.166	51.766	80.336	108.966	137.566	166.166	194.766	223.366	251.966	280.566
82	23.452	52.052	80.652	109.252	137.852	166.452	195.052	223.652	252.252	280.852
83	23.738	52.338	80.938	109.538	138.138	166.738	195.338	223.938	252.538	281.138
84	24.024	52.624	81.224	109.824	138.424	167.024	195.624	224.224	252.824	281.424
85	24.310	52.910	81.510	110.110	138.710	167.310	195.910	224.510	253.110	281.710
86	24.596	53.196	81.796	110.396	138.996	167.596	196.196	224.796	253.396	281.996
87	24.882	53.482	82.082	110.682	139.282	167.882	196.482	225.082	253.682	282.282
88	25.168	53.768	82.368	110.968	139.568	168.168	196.768	225.368	253.968	282.568
89	25.454	54.054	82.654	111.254	139.854	168.454	197.054	225.654	254.254	282.854
90	25.740	54.340	82.940	111.540	140.140	168.740	197.340	225.940	254.540	283.140
91	26.026	54.626	83.226	111.826	140.426	169.026	197.626	226.226	254.826	283.426
92	26.312	54.912	83.512	112.112	140.712	169.312	197.912	226.512	255.112	283.712
93	26.598	55.198	83.798	112.398	140.998	169.598	198.198	226.798	255.398	283.998
94	26.884	55.484	84.084	112.684	141.284	169.884	198.484	227.084	255.684	284.284
95	27.170	55.770	84.370	112.970	141.570	170.170	198.770	227.370	255.970	284.570
96	27.456	56.056	84.656	113.256	141.856	170.456	199.056	227.656	256.256	284.856
97	27.742	56.342	84.942	113.542	142.142	170.742	199.342	227.942	256.542	285.142
98	28.028	56.628	85.228	113.828	142.428	171.028	199.628	228.228	256.828	285.428
99	28.314	56.914	85.514	114.114	142.714	171.314	199.914	228.514	257.114	285.714
100	28.600	57.200	85.800	114.400	143.000	171.600	200.200	228.800	257.400	286.000

TABLE CONVERTING MILLIMETERS TO INCHES

Based on 1 millimeter = 0.03937 inch.

Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.
1	.03937	51	2.00787	101	3.97637	151	5.94487	201	7.91337
2	.07874	52	2.04724	102	4.01574	152	5.98424	202	7.95274
3	.11811	53	2.08661	103	4.05511	153	6.02361	203	7.99211
4	.15748	54	2.12598	104	4.09448	154	6.06298	204	8.03148
5	.19685	55	2.16535	105	4.13385	155	6.10235	205	8.07085
6	.23622	56	2.20472	106	4.17322	156	6.14172	206	8.11022
7	.27559	57	2.24409	107	4.21259	157	6.18109	207	8.14959
8	.31496	58	2.28346	108	4.25196	158	6.22046	208	8.18896
9	.35433	59	2.32283	109	4.29133	159	6.25983	209	8.22833
10	.39370	60	2.36220	110	4.33070	160	6.29920	210	8.26770
11	.43307	61	2.40157	111	4.37007	161	6.33857	211	8.30707
12	.47244	62	2.44094	112	4.40944	162	6.37794	212	8.34644
13	.51181	63	2.48031	113	4.44881	163	6.41731	213	8.38581
14	.55118	64	2.51968	114	4.48818	164	6.45668	214	8.42518
15	.59055	65	2.55905	115	4.52755	165	6.49605	215	8.46455
16	.62992	66	2.59842	116	4.56692	166	6.53542	216	8.50392
17	.66929	67	2.63779	117	4.60629	167	6.57479	217	8.54329
18	.70866	68	2.67716	118	4.64566	168	6.61416	218	8.58266
19	.74803	69	2.71653	119	4.68503	169	6.65353	219	8.62203
20	.78740	70	2.75590	120	4.72440	170	6.69290	220	8.66140
21	.82677	71	2.79527	121	4.76377	171	6.73227	221	8.70077
22	.86614	72	2.83464	122	4.80314	172	6.77164	222	8.74014
23	.90551	73	2.87401	123	4.84251	173	6.81101	223	8.77951
24	.94488	74	2.91338	124	4.88188	174	6.85038	224	8.81888
25	.98425	75	2.95275	125	4.92125	175	6.88975	225	8.85825
26	1.02362	76	2.99212	126	4.96062	176	6.92912	226	8.89762
27	1.06299	77	3.03149	127	4.99999	177	6.96849	227	8.93699
28	1.10236	78	3.07086	128	5.03936	178	7.00786	228	8.97636
29	1.14173	79	3.11023	129	5.07873	179	7.04723	229	9.01573
30	1.18110	80	3.14960	130	5.11810	180	7.08660	230	9.05510
31	1.22047	81	3.18897	131	5.15747	181	7.12597	231	9.09447
32	1.25984	82	3.22834	132	5.19684	182	7.16534	232	9.13384
33	1.29921	83	3.26771	133	5.23621	183	7.20471	233	9.17321
34	1.33858	84	3.30708	134	5.27558	184	7.24408	234	9.21258
35	1.37795	85	3.34645	135	5.31495	185	7.28345	235	9.25195
36	1.41732	86	3.38582	136	5.35432	186	7.32282	236	9.29132
37	1.45669	87	3.42519	137	5.39369	187	7.36219	237	9.33069
38	1.49606	88	3.46456	138	5.43306	188	7.40156	238	9.37006
39	1.53543	89	3.50393	139	5.47243	189	7.44093	239	9.40943
40	1.57480	90	3.54330	140	5.51180	190	7.48030	240	9.44880
41	1.61417	91	3.58267	141	5.55117	191	7.51967	241	9.48817
42	1.65354	92	3.62204	142	5.59054	192	7.55904	242	9.52754
43	1.69291	93	3.66141	143	5.62991	193	7.59841	243	9.56691
44	1.73228	94	3.70078	144	5.66928	194	7.63778	244	9.60628
45	1.77165	95	3.74015	145	5.70865	195	7.67715	245	9.64565
46	1.81102	96	3.77952	146	5.74802	196	7.71652	246	9.68502
47	1.85039	97	3.81889	147	5.78739	197	7.75589	247	9.72439
48	1.88976	98	3.85826	148	5.82676	198	7.79526	248	9.76376
49	1.92913	99	3.89763	149	5.86613	199	7.83463	249	9.80313
50	1.96850	100	3.93700	150	5.90550	200	7.87400	250	9.84250

TABLE CONVERTING MILLIMETERS TO INCHES
(Continued)

Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.
251	9.88187	301	11.85037	351	13.81887	401	15.78737	451	17.75587
252	9.92124	302	11.88974	352	13.85824	402	15.82674	452	17.79524
253	9.96061	303	11.92911	353	13.89761	403	15.86611	453	17.83461
254	9.99998	304	11.96848	354	13.93698	404	15.90548	454	17.87398
255	10.03935	305	12.00785	355	13.97635	405	15.94485	455	17.91335
256	10.07872	306	12.04722	356	14.01572	406	15.98422	456	17.95272
257	10.11809	307	12.08659	357	14.05509	407	16.02359	457	17.99209
258	10.15746	308	12.12596	358	14.09446	408	16.06296	458	18.03146
259	10 19683	309	12.16533	359	14.13383	409	16.10233	459	18.07383
260	10.23620	310	12.20470	360	14.17320	410	16.14170	460	18.11020
261	10 27557	311	12.24407	361	14.21257	411	16.18107	461	18.14957
262	10.31494	312	12.28344	362	14.25194	412	16.22044	462	18.18894
263	10.35431	313	12.32281	363	14.29131	413	16.25981	463	18.22831
264	10.39368	314	12.36218	364	14.33063	414	16.29918	464	18.26768
265	10.43305	315	12.40155	365	14.37005	415	16.33855	465	18.30705
266	10.47242	316	12.44092	366	14.40942	416	16.37792	466	18.34642
267	10.51179	317	12 48029	367	14.44879	417	16.41729	467	18.38579
268	10.55116	318	12.51966	368	14.48816	418	16.45666	468	18 42516
269	10.59053	319	12.55903	369	14.52753	419	16.49603	469	18.46453
270	10.62990	320	12.59840	370	14.56690	420	16.53540	470	18.50390
271	10.66927	321	12.63777	371	14.60627	421	16.57477	471	18.54327
272	10.70864	322	12.67714	372	14.64564	422	16.61414	472	18.58264
273	10.74801	323	12.71651	373	14 68501	423	16.65351	473	18.62201
274	10.78738	324	12.75588	374	14.72438	424	16.69288	474	18.66138
275	10.82675	325	12.79525	375	14.76375	425	16.73225	475	18.70075
276	10.86612	326	12.83462	376	14.80312	426	16.77162	476	18.74012
277	10.90549	327	12.87399	377	14 84249	427	16.81099	477	18.77949
278	10.94486	328	12.91336	378	14.88186	428	16.85036	478	18.81886
279	10.98423	329	12.95273	379	14.92123	429	16.88973	479	18.85823
280	11.02360	330	12 99210	380	14.96060	430	16.92910	480	18.89760
281	11.06297	331	13.03147	381	14.99997	431	16.96847	481	18.93697
282	11.10234	332	13.07084	382	15.03934	432	17.00784	482	18.97634
283	11.14171	333	13.11021	383	15.07871	433	17.04721	483	19.01571
284	11.18108	334	13 14958	384	15.11808	434	17.08658	484	19.05508
285	11.22045	335	13.18895	385	15.15745	435	17.12595	485	19.09445
286	11.25982	336	13 22832	386	15.19682	436	17.16532	486	19.13382
287	11.29919	337	13.26769	387	15.23619	437	17.20469	487	19.17319
288	11.33856	338	13.30706	388	15.27556	438	17.24406	488	19.21256
289	11.37793	339	13.34643	389	15.31493	439	17.28343	489	19.25193
290	11.41730	340	13.38580	390	15.35430	440	17.32280	490	19.29130
291	11.45667	341	13.42517	391	15.39367	441	17.36217	491	19.33067
292	11.49604	342	13.46454	392	15.43304	442	17.40154	492	19.37004
293	11.53541	343	13.50391	393	15.47241	443	17.44091	493	19.40941
294	11.57478	344	13.54328	394	15.51178	444	17.48028	494	19.44878
295	11.61415	345	13.58265	395	15.55115	445	17.51965	495	19.48815
296	11.65352	346	13.62202	396	15.59052	446	17.55902	496	19.52752
297	11.69289	347	13.66139	397	15.62989	447	17.59839	497	19.56689
298	11 73226	348	13.70076	398	15.66926	448	17.63776	498	19.60626
299	11.77163	349	13.74013	399	15.70863	449	17.67713	499	19.64563
300	11.81100	350	13.77950	400	15.74800	450	17.71650	500	19.68500

TABLE CONVERTING MILLIMETERS TO INCHES
(Continued)

Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.
501	19.72437	551	21.69287	601	23.66137	651	25.62987	701	27.59837
502	19.76374	552	21.73224	602	23.70074	652	25.66924	702	27.63774
503	19.80311	553	21.77161	603	23.74011	653	25.70861	703	27.67711
504	19.84248	554	21.81098	604	23.77948	654	25.74798	704	27.71648
505	19.88185	555	21.85035	605	23.81885	655	25.78735	705	27.75585
506	19.92122	556	21.88972	606	23.85822	656	25.82672	706	27.79522
507	19.96059	557	21.92909	607	23.89759	657	25.86609	707	27.83459
508	19.99996	558	21.96846	608	23.93696	658	25.90546	708	27.87396
509	20.03933	559	22.00783	609	23.97633	659	25.94483	709	27.91333
510	20.07870	560	22.04720	610	24.01570	660	25.98420	710	27.95270
511	20.11807	561	22.08657	611	24.05507	661	26.02357	711	27.99207
512	20.15744	562	22.12594	612	24.09444	662	26.06294	712	28.03144
513	20.19681	563	22.16531	613	24.13381	663	26.10231	713	28.07081
514	20.23618	564	22.20468	614	24.17318	664	26.14168	714	28.11018
515	20.27555	565	22.24405	615	24.21255	665	26.18105	715	28.14955
516	20.31492	566	22.28342	616	24.25192	666	26.22042	716	28.18892
517	20.35429	567	22.32279	617	24.29129	667	26.25979	717	28.22829
518	20.39366	568	22.36216	618	24.33066	668	26.29916	718	28.26766
519	20.43303	569	22.40153	619	24.37003	669	26.33853	719	28.30703
520	20.47240	570	22.44090	620	24.40940	670	26.37790	720	28.34640
521	20.51177	571	22.48027	621	24.44877	671	26.41727	721	28.38577
522	20.55114	572	22.51964	622	24.48814	672	26.45664	722	28.42514
523	20.59051	573	22.55901	623	24.52751	673	26.49601	723	28.46451
524	20.62988	574	22.59838	624	24.56688	674	26.53538	724	28.50388
525	20.66925	575	22.63775	625	24.60625	675	26.57475	725	28.54325
526	20.70862	576	22.67712	626	24.64562	676	26.61412	726	28.58262
527	20.74799	577	22.71649	627	24.68499	677	26.65349	727	28.62199
528	20.78736	578	22.75586	628	24.72436	678	26.69286	728	28.66136
529	20.82673	579	22.79523	629	24.76373	679	26.73223	729	28.70073
530	20.86610	580	22.83460	630	24.80310	680	26.77160	730	28.74010
531	20.90547	581	22.87397	631	24.84247	681	26.81097	731	28.77947
532	20.94484	582	22.91334	632	24.88184	682	26.85034	732	28.81884
533	20.98421	583	22.95271	633	24.92121	683	26.88971	733	28.85821
534	21.02358	584	22.99208	634	24.96058	684	26.92908	734	28.89758
535	21.06295	585	23.03145	635	24.99995	685	26.96845	735	28.93695
536	21.10232	586	23.07082	636	25.03932	686	27.00782	736	28.97632
537	21.14169	587	23.11019	637	25.07869	687	27.04719	737	29.01569
538	21.18106	588	23.14956	638	25.11806	688	27.08656	738	29.05506
539	21.22043	589	23.18893	639	25.15743	689	27.12593	739	29.09443
540	21.25980	590	23.22830	640	25.19680	690	27.16530	740	29.13380
541	21.29917	591	23.26767	641	25.23617	691	27.20467	741	29.17317
542	21.33854	592	23.30704	642	25.27554	692	27.24404	742	29.21254
543	21.37791	593	23.34641	643	25.31491	693	27.28341	743	29.25191
544	21.41728	594	23.38578	644	25.35428	694	27.32278	744	29.29128
545	21.45665	595	23.42515	645	25.39365	695	27.36215	745	29.33068
546	21.49602	596	23.46452	646	25.43302	696	27.40152	746	29.37002
547	21.53539	597	23.50389	647	25.47239	697	27.44089	747	29.40939
548	21.57476	598	23.54326	648	25.51176	698	27.48026	748	29.44876
549	21.61413	599	23.58263	649	25.55113	699	27.51963	749	29.48813
550	21.65350	600	23.62200	650	25.59050	700	27.55900	750	29.52750

TABLE CONVERTING MILLIMETERS TO INCHES
(Concluded)

Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.
751	29.56687	801	31.53537	851	33.50387	901	35.47237	951	37.44087
752	29.60624	802	31.57474	852	33.54324	902	35.51174	952	37.48024
753	29.64561	803	31.61411	853	33.58261	903	35.55111	953	37.51961
754	29.68498	804	31.65348	854	33.62198	904	35.59048	954	37.55898
755	29.72435	805	31.69285	855	33.66135	905	35.62985	955	37.59835
756	29.76372	806	31.73222	856	33.70072	906	35.66922	956	37.63772
757	29.80309	807	31.77159	857	33.74009	907	35.70859	957	37.67709
758	29.84246	808	31.81096	858	33.77946	908	35.74796	958	37.71646
759	29.88183	809	31.85033	859	33.81883	909	35.78733	959	37.75583
760	29.92120	810	31.88970	860	33.85820	910	35.82670	960	37.79520
761	29.96057	811	31.92907	861	33.89757	911	35.86607	961	37.83457
762	29.99994	812	31.96844	862	33.93694	912	35.90544	962	37.87394
763	30.03931	813	32.00781	863	33.97631	913	35.94481	963	37.91331
764	30.07868	814	32.04718	864	34.01568	914	35.98418	964	37.95268
765	30.11805	815	32.08655	865	34.05505	915	36.02355	965	37.99205
766	30.15742	816	32.12592	866	34.09442	916	36.06292	966	38.03142
767	30.19679	817	32.16529	867	34.13379	917	36.10229	967	38.07079
768	30.23616	818	32.20466	868	34.17316	918	36.14166	968	38.11016
769	30.27553	819	32.24403	869	34.21253	919	36.18103	969	38.14953
770	30.31490	820	32.28340	870	34.25190	920	36.22040	970	38.18890
771	30.35427	821	32.32277	871	34.29127	921	36.25977	971	38.22827
772	30.39364	822	32.36214	872	34.33064	922	36.29914	972	38.26764
773	30.43301	823	32.40151	873	34.37001	923	36.33851	973	38.30701
774	30.47238	824	32.44088	874	34.40938	924	36.37788	974	38.34638
775	30.51175	825	32.48025	875	34.44875	925	36.41725	975	38.38575
776	30.55112	826	32.51962	876	34.48812	926	36.45662	976	38.42512
777	30.59049	827	32.55899	877	34.52749	927	36.49599	977	38.46449
778	30.62986	828	32.59836	878	34.56686	928	36.53536	978	38.50386
779	30.66923	829	32.63773	879	34.60623	929	36.57473	979	38.54323
780	30.70860	830	32.67710	880	34.64560	930	36.61410	980	38.58260
781	30.74797	831	32.71647	881	34.68497	931	36.65347	981	38.62197
782	30.78734	832	32.75584	882	34.72434	932	36.69284	982	38.66134
783	30.82671	833	32.79521	883	34.76371	933	36.73221	983	38.70071
784	30.86608	834	32.83458	884	34.80308	934	36.77158	984	38.74008
785	30.90545	835	32.87395	885	34.84245	935	36.81095	985	38.77945
786	30.94482	836	32.91332	886	34.88182	936	36.85032	986	38.81882
787	30.98419	837	32.95269	887	34.92119	937	36.88969	987	38.85819
788	31.02356	838	32.99206	888	34.96056	938	36.92906	988	38.89756
789	31.06293	839	33.03143	889	34.99993	939	36.96843	989	38.93693
790	31.10230	840	33.07080	890	35.03930	940	37.00780	990	38.97630
791	31.14167	841	33.11017	891	35.07867	941	37.04717	991	39.01567
792	31.18104	842	33.14954	892	35.11804	942	37.08654	992	39.05504
793	31.22041	843	33.18891	893	35.15741	943	37.12591	993	39.09441
794	31.25978	844	33.22828	894	35.19678	944	37.16528	994	39.13378
795	31.29915	845	33.26765	895	35.23615	945	37.20465	995	39.17315
796	31.33852	846	33.30702	896	35.27552	946	37.24402	996	39.21252
797	31.37789	847	33.34639	897	35.31489	947	37.28339	997	39.25189
798	31.41726	848	33.38576	898	35.35426	948	37.32276	998	39.29126
799	31.45663	849	33.42513	899	35.39363	949	37.36213	999	39.33063
800	31.49600	850	33.46450	900	35.43300	950	37.40150	1,000	39.37000

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